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A SURVEY OF AVERAGE DRIVING PATTERNS IN THE LOS ANGELES URBAN AREA

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A SURVEY OF AVERAGE DRIVING PATTERNS IN THE LOS ANGELES URBAN AREA

D. H. Kearin
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February 28, 1969

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D. H. Kearin
Project Manager

INTRODUCTION

System Development Corporation (SDC) has performed a study to survey the characteristic use patterns of privately operated automobiles in the Los Angeles urban area. The study was conducted under research contract to the Coordinating Research Council, Inc., (CRC). The purpose of the study was to obtain data necessary to develop a composite average driving pattern that would serve as a basis for designing new test cycles for vehicle emission control devices. The collection, reduction, and analysis of these data are the subject of this report.

During the study SDC installed automatic information recording devices--called Tachographs--in 199 privately operated automobiles volunteered by Los Angeles area residents. The data records from these instruments as well as information obtained from log books maintained by each of the volunteer participants have been reduced and analyzed. This document presents a description of the techniques used to obtain and analyze the data and a discussion of the study results.

The report is organized in three parts. The first presents the results of the study in narrative and tabular form as well as an analysis and evaluation of the study findings. The second part discusses the survey technique in terms of general procedures, sample design and selection, and data collection. The third part details the data reduction and analysis procedures. In addition, appendices are included which provide amplifying data for the entire document.

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PART I

RESULTS OF STUDY

This chapter presents the results of the Survey of Average Driving Patterns in the Los Angeles urban area. The results are organized into two sections. The first presents a detailed description of the several average or typical[1] driving patterns that were developed from a statistical analysis of the survey data. The second section presents a summary description of the data base from which the typical patterns were derived.

TYPICAL DRIVING PATTERNS

SDC's intent in deriving the typical driving patterns described below has been to extract from a vast amount of information collected during the survey a fairly detailed quantitative and qualitative description of those patterns which clearly stand out as typical. While the data base is large, it is not so large that the analyst can, with great confidence, probe very deeply into the intricacies of secondary or tertiary patterns. Nevertheless, in view of the scarcity of previous results in this area of study, particularly from the standpoint of enlisting the public's aid in the data collection effort, the results presented here represent a substantial contribution to our knowledge of automobile utilization--even if they only serve to reinforce what have heretofore been intuitive concepts about how people drive their cars.

A typical driving pattern is described in terms of a day's sequence of trips that all start at approximately the same time, have the same trip segment string (i.e., have identical patterns of freeway and nonfreeway usage), and which sequence of trips can be explained by a reasonable scenario of driver behavior. The patterns described below are those which stand out clearly in the results of the analysis. Part of the description of each pattern is an indication of the percentage of the entire survey sample represented by the pattern as well as the percentage of the n-trip sample which is characterized by the n-trip pattern.

---

[1] SDC prefers the term "typical" to the term "average" since the latter has the connotation of an arithmetic mean which in the present case is not entirely appropriate. The typical driving patterns are, in most aspects of the analysis, derived from modes rather than means in the statistical sense.

Table 1-1 shows the distribution of weekdays and weekend days upon which survey participants drove their cars on n-trips. In the survey, n varied from zero to 17 on weekdays and from zero to 15 on weekends. The table shows that the occurrence of days on which more than six trips were driven drops off quickly compared to days on which six or less were driven. Partly because of the dropoff in sample size as the number of trips increased and partly because the potential number of trip patterns increases geometrically as the number of trips per day increases, patterns were discovered only for two, three, four, and five trip sequences.

No clear-cut patterns were discernible for weekend driving. The time distribution of weekend trips is quite different from that of weekday trips | (see Figure 1-12 and 1-13). To some extent this difference may be more marked in our survey due to the composition of the survey population. All participants in the survey were contacted through their place of employment. As a result, the daily work schedule imposed upon a working employee tends to be reflected in the survey results. Weekday-weekend differences are discussed more fully in the General Results section of this chapter.

Some rather startling, and as yet not fully explained, differences were noted in the distribution of n-trip weekdays. Figure 1-1 shows the distribution of n-trip days for all seven days of the week.

TABLE 1-1

DAILY DISTRIBUTION OF N-TRIP DAYS IN LOS ANGELES DRIVING PATTERNS SURVEY

NUMBER OF TRIPS PER DAY (N)	NUMBER OF N-TRIP DAYS						
	M	T	W	TH	F	S	S
0	12	7	7	9	8	28	41
1	4	6	9	11	5	7	5
2	40	27	36	33	30	23	19
3	16	30	16	26	15	18	18
4	34	27	29	25	30	12	19
5	23	19	16	18	23	13	18
6	15	16	15	10	16	19	17
7	8	10	13	8	13	5	10
8	6	11	8	13	5	12	4
9	3	3	3	3	8	12	3
10	3	2	4	7	2	2	1
11	1	1	3	1	3	4	1
12	1	1	1	0	1	3	2
13	2	2	1	1	2	2	0
14	0	0	0	1	2	0	0
15	1	1	0	0	1	0	1
16	0	1	1	0	0	0	0
17	0	0	0	0	1	0	0

A glance at Figure 1-1 clearly shows that the distribution of three-trip weekdays is highly dependent on the day of the week. On Tuesday and Thursday, three-trip days constitute respectively 18.3 percent and 15.7 percent of all n-trip days while on Monday, Wednesday, and Friday the corresponding percentages are 9.5 percent, 9.8 percent, and 9.1 percent. The data do not provide us an explanation of this disparity, but we are led to speculate that perhaps on Tuesdays and Thursdays the breadwinner in the family is more likely to stop at the store on the way home from work to replenish the family's food supply. Another daily difference noted in Figure 1-1 is the increase in zero-trip days on weekends which is to be expected.

Returning to the typical n-trip day patterns, differences in the occurrence of particular trip segment strings require that two alternative trips be considered as components of the pattern in certain cases. Also, two distinct patterns for the four-trip day were discovered that require alternative descriptions.

The following sections of the chapter describe each sequence, or pattern, of trips in terms of a scenario and a table of values for such trip descriptors as start time, trip and segment distance, segment average speed, number of momentary stops (idles) per segment, idling time per segment, route types, and purpose of trip. The quantities tabulated for start time, distance, average speed, number of momentary stops (idles), idling time, route type and purpose of trip are the mean values associated with trips and segments that are defined by the specified time slot, purpose, and trip segment string. Adjacent to these values are ranges within which at least 75 percent of the data lie. These ranges are obtained by examining a printout of the distribution of cases for each variable as specified by time slot, purpose, and trip segment string. In the printout, variables are grouped into class intervals. The class intervals used by the program are as follows:

Distance: 3-mile intervals from 0 miles to 50 miles.
Average speed: 5-mph intervals from 0 mph to 75 mph.
Momentary stops: 2-stop intervals from 0 to 30 stops.
Idling time: 2-minute intervals from 0 to 10 minutes.

To calculate the 75 percent ranges for distance, speed, and idling time, the analyst starts with the class interval that contains the mean, and working away from that interval in both directions, sums the number of cases until he has included at least 75 percent of them. The number he accumulates in each direction depends on the way the data are distributed. For distributions skewed in the lower direction, more cases will be picked up below the mean. For symmetrical distributions, the range will be more balanced. The time slots used for grouping the data were agreed upon earlier by CRC[1] and SDC. Weekdays are divided into eight time slots, weekend-days into six. Table 1-2 shows the organization of the time slot structure.

TABLE 1-2

TIME SLOT STRUCTURE USED IN LOS ANGELES DRIVING PATTERNS SURVEY

TIME SLOT NUMBER	TIME PERIOD (24 HOUR CLOCK)	
	WEEKDAY	WEEKEND
1	0000-0559	0000-0829
2	0600-0859	0830-1059
3	0900-1129	1100-1259
4	1130-1329	1300-1759
5	1330-1629	1800-2059
6	1630-1829	2100-2359
7	1830-2059	–
8	2100-2359	–

The time distribution of all trip start times are shown in Figures 1-12 and 1-13 in the General Results section of this chapter.

---

[1] CRC-APRAC Project Groups CAPE-5 and CAPE-10

The elapsed time for each component trip of a typical trip pattern is based on completing the mean trip or segment distance at the mean average speed. The reason for calculating mean elapsed time from mean distance and mean average speed is twofold. First, as described in the pattern descriptions, certain trip distances are derived artificially so that no data on real elapsed time over these distances are available. Second, and more important, the Tachograph provides distance and elapsed time for each trip from which exact average speed values are calculated. The values of these three variables are, however, from the standpoint of the computer continuously distributed. In order to meet computer storage requirements and to obtain distribution information, these variables must be grouped or classified into the class intervals previously listed. Once this is done, mean speed, mean trip distance and mean elapsed time are no longer functionally related in exact terms since all calculations use the midpoint of the class interval to represent all values within that interval. Therefore, the authors believe that the average speed and average distance are more "real" intuitively since they are descriptive of actual, not artificial, phenomena that occurred during the survey, and that elapsed time can best be calculated using the mean values for these variables rather than using the mean values for time and distance to calculate mean average speed.[1] Variations over the ranges for distance and speed will, of course, cause differences in the elapsed time of the trip or segment.

A general description of the method used in deriving these patterns is contained in the Statistical Analysis section of Part III of the report. The section on general results that follows the description of the typical trip patterns discusses in greater detail the quantitative basis for the patterns described.

---

[1] In addition, the problem of outlying data enters into this consideration. This problem is discussed in Part III.

The Two-Trip Day

Figure 1-2 shows the time dependency distribution of all two-trip weekdays that occurred during the survey period. The presentation is in the form of a trip-to-trip transition matrix. The matrix is set up as follows: All trips are assigned a time slot value based on the time slot into which one-half or more of the total trip time falls. These time slot values for all trips one and two on two-trip days were analyzed to determine into which cell of the trip-to-trip transition matrix the days record would be counted. The time slot value for trip one established the row for the entry, the time slot value for trip two established the column. Therefore, if a trip one occurred in time slot two followed by a trip two in time slot six, the record for that day was associated with cell 26 at the intersection of the second row and the sixth column. In addition to the slot dependencies, the analysis also provided counts for purpose-to-purpose dependencies within each time slot cell. It is from these latter dependencies that the literal entries in Figure 1-2 indicating the typical purpose-to-purpose pairs are obtained. In Figure 1-2 and subsequent trip-to-trip transition matrices these literal entries are made only for cells with a high frequency trip entries and then only if a particular purpose pair stands out.

TO TIME SLOT		0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
FROM TIME SLOT	0000-0559	2	0	0	0	0	0	1	0
	0600-0859		3	0	0	15 W-H	82 W-H	7	1
	0900-1129			0	2	0	1	1	1
	1130-1329				0	0	1	0	0
	1330-1629					7	25 W-H	1	1
	1630-1829						5	4	3
	1830-2059							1	3
	2100-2359								0

TRIP ONE TO TRIP TWO

TOTAL TWO-TRIP WEEKDAYS: 167

LEGEND

H - Home
W - Work
B - Business
S - Shopping
C - Church, School, etc.
R - Recreation

FIGURE 1-2

TWO-TRIP WEEKDAY TRANSITION MATRIX

From Figure 1-2, we see that the highest frequency count occurs in cell 26 with 82 two-trip days showing the transition. Of these 82, 73 show the purpose-to-purpose combination of a trip one, to work, followed by a trip two, to home. That this is a typical trip pattern is clear. Reinforcement is added by the fact that 14 trips in the adjacent cell 25 as well as four trips in cell 27 show the same purpose-to-purpose structure. If one assumes that the 14 represent people with early quitting times, say between 4:00 and 4:30 p.m. while the four represent overtime workers, then the analysis shows that between 73 out of 167 (44%) and 91 out of 167 (54%) of the two-trip days fit our typical pattern. This range represents between 6.4% and 7.9% of the total car-days in the survey.

The values for the typical two-trip pattern are shown in Table 1-3. In the first column, entitled Trip Number, the letter "A" represents a nonfreeway trip while the letter "B" represents a freeway trip. The trip-to-work in time slot two is equally likely to have a trip segment sequence of nonfreeway only or nonfreeway/freeway/nonfreeway (the survey contained 277 of the former, 294 of the latter). The data for return trips home in time slot six is confused by the incidence of return trips from origination points other than work. But it is unreasonable to assume that the typical return trip from work would have any other structure than that of the original morning trip. Therefore, the distances shown in Table 1-3 for the evening trip are the same as those in the morning trip. The average speeds for both trips are those characteristic of the time slot, purpose, and trip segment string described. The elapsed times are calculated from these values.

The Three-Trip Day

Figures 1-3 and 1-4 show the two trip-to-trip transition matrices for the three-trip day. The matrix in Figure 1-3 shows the transition from trip one to trip two; that in Figure 1-4 from trip two to trip three. Certain anomalies in the matrices for the three trip and succeeding n-trip days will be noted. In any given matrix chain, the $j^{\underline{th}}$ column total in the $n^{\underline{th}}$ matrix should equal the $j^{\underline{th}}$ row total in the $(n+1)^{\underline{st}}$ matrix. Unfortunately, this is not always the case due to what appear to be random errors in the basic data tape. This problem has not yet been fully diagnosed but has been examined to the point where we are sure that the errors are random and not systematic so that, in the main, the data are accurate.

TABLE 1-3

THE TYPICAL TWO-TRIP DAY PATTERN

(REPRESENTS 44% - 54% OF ALL TWO-TRIP DAYS, 6.4% - 7.9% OF ALL CAR-DAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME		MEAN ELAPSED TIME (MIN)	DISTANCE (MILES)		AVERAGE SPEED (MPH)		NUMBER OF STOPS (IDLES)		IDLE TIME (MIN)	
				MEAN	RANGE*		MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**
1A	WORK	1	NF	0722	0645 - 0759	15.3	5.8	0.1 - 9.0	22.7	15.0 - 35.0	11.8	4.0 - 22.0	3.6	1.0 - 8.0
	OR:													
1B	WORK	1	NF	0712	0635 - 0749	8.9	4.2	0.1 - 6.0	28.3	15.0 - 45.0	4.3	2.0 - 12.0	1.3	0.0 - 2.0
		2	F			12.2	7.7	2.0 - 21.0	37.7	20.0 - 55.0	1.5	0.0 - 2.0	0.3	0.0 - 1.0
		3	NF			8.6	3.4	0.1 - 6.0	23.6	10.0 - 40.0	4.5	2.0 - 12.0	1.4	0.0 - 2.0
						29.7	15.3				10.3		3.0	
(TRIPS 1A AND 1B OCCUR IN EQUAL NUMBER)														
2A	HOME	1	NF	1722	1649 - 1755	15.5	5.8	0.1 - 9.0	22.5	10.0 - 35.0	10.5	4.0 - 22.0	2.9	1.0 - 6.0
	OR:													
2B	HOME	1	NF	1707	1634 - 1740	8.4	3.4	0.1 - 6.0	24.2	10.0 - 45.0	6.9	2.0 - 16.0	1.4	0.0 - 3.0
		2	F			12.4	7.7	2.0 - 21.0	37.1	20.0 - 60.0	2.3	0.0 - 3.0	0.4	0.0 - 1.0
		3	NF			10.7	4.2	0.1 - 6.0	23.6	10.0 - 40.0	4.9	2.0 - 12.0	1.9	0.0 - 3.0
						31.5	15.3							
(TRIPS 2A AND 2B OCCUR IN EQUAL NUMBER)														

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

TO TIME SLOT FROM TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	1	1	1	0	0	0	0
0600-0859		11 S,B-W	6	4	7	33 W-S	3	1
0900-1129			1	0	0	1	0	0
1130-1329				2	2	1	0	0
1330-1629					5	13 W-H W-S	1	0
1630-1829						2	5	0
1830-2059							2	0
2100-2359								0

TRIP ONE TO TRIP TWO

TOTAL THREE TRIP WEEKDAYS: 103

LEGEND

H - Home
W - Work
B - Business
S - Shopping
C - Church, School, etc.
R - Recreation

FIGURE 1-3

THREE-TRIP WEEKDAY TRANSITION MATRIX

TO TIME SLOT

FROM TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	0	0	0	0	0	0	0
0600-0859		0	0	0	1	9 W-H	0	0
0900-1129			1	4	0	1	0	1
1130-1329				2	0	4	1	0
1330-1629					4	13 S,W-H	1	0
1630-1829						24 S-H	20 S-H	5
1830-2059							6	5
2100-2359								1

TRIP TWO TO TRIP THREE

LEGEND

H - Home
W - Work
B - Business
S - Shopping
C - Church, School, etc.
R - Recreation

FIGURE 1-4

THREE-TRIP WEEKDAY TRANSITION MATRIX

The predominant transition in the first matrix is from a first trip in time slot two to a second trip in time slot six. Thirty three-out of 103 three-trip days (32%) show this pattern. Of these 33, 21 transition from a work trip to a shopping trip. The second matrix shows the highest frequencies to be those of transitioning from a second trip in time slot six to a third trip in either time slot six or seven, 24 in the first category (23%) and 20 in the second (19%). Of these 44 trips, 29 transition from a shopping trip to a home trip, 19 in time slot six, and 10 in time slot seven. Assuming that some of the 10 occur early in time slot seven, then it is fair to assume that 19 or more out of 103 cars (18%) carried out the typical three-trip day pattern: a trip to work in the morning, a shopping trip in the evening after work, followed by a trip home. These 19 car-days represent 1.6% of the total car-days in the survey.

Table 1-4 contains the values describing the typical three-trip day pattern. In calculating results for the trip 2A-3A combination, the total distance of trip 1A is allocated between trips 2A and 3A in proportion to the mean distances of shopping trips and home trips in time slot six.

The distribution of trip purposes and trip segment strings in time slot six shows a high degree of correlation between shopping trips and the nonfreeway/freeway/nonfreeway segment structure. There are 51 trips in this category but the "expected" frequency[1] is only 31. This correlation corresponds to that between work trips and the same trip segment structure in time slot two. Consequently, we believe that the destination for the shopping trip is typically reached after, rather than before the driver enters the freeway portion of the trip. Consequently, for the trip 2B-3B combination, the total distance covered by the two trips is obtained by using the same average distance as that for morning work trips with the trip segment structure nonfreeway/freeway/nonfreeway. This distance is allocated between trips 2B and 3B by subtracting the mean distance for shopping trips with the segment structure nonfreeway/freeway/nonfreeway in time slot six (12.9 mi)

---

[1] Described later in the General Results section of this part of the report.

TABLE 1-4

THE TYPICAL THREE-TRIP DAY PATTERN

(REPRESENTS 18% OF ALL THREE-TRIP DAYS, 1.6% OF ALL CAR-DAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME		MEAN ELAPSED TIME (MIN)	DISTANCE (MILES)		AVERAGE SPEED (MPH)		NUMBER OF STOPS (IDLES)		IDLE TIME (MIN)	
				MEAN	RANGE*		MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**
1A	WORK	1	NF	0722	0645 - 0759	15.3	5.8	0.1 - 9.0	22.7	15.0 - 35.0	11.8	4.0 - 22.0	3.6	1.0 - 8.0
	OR:													
1B	WORK	1	NF	0712	0635 - 0749	8.9	4.2	0.1 - 6.0	28.3	15.0 - 45.0	4.3	2.0 - 12.0	1.3	0.0 - 2.0
		2	F			12.2	7.7	2.0 - 21.0	37.7	20.0 - 55.0	1.5	0.0 - 2.0	0.3	0.0 - 1.0
		3	NF			8.6	3.4	0.1 - 6.0	23.6	10.0 - 40.0	4.5	2.0 - 12.0	1.4	0.0 - 2.0
						29.7	15.3				10.3		3.0	
(TRIPS 1A AND 1B OCCUR IN EQUAL NUMBER)														
2A	SHOP			1724	1653 - 1755	7.2	2.6	0.1 - 4.0	21.8	10.0 - 35.0	5.7	0.0 - 10.0	1.7	0.0 - 2.0
3A	HOME			1754	–	8.5	3.2	0.1 - 5.0	22.5	10.0 - 35.0	7.2	0.0 - 14.0	2.0	0.0 - 5.0
	OR:													
2B	SHOP	1	NF	1700	1632 - 1728	8.4	3.4	0.1 - 6.0	24.4	10.0 - 40.0	5.3	0.0 - 6.0	1.4	0.0 - 3.0
		2	F			12.9	7.7	2.0 - 21.0	35.8	25.0 - 55.0	1.9	0.0 - 2.0	0.3	0.0 - 1.0
		3	NF			3.5	1.6	0.1 - 3.0	27.2	15.0 - 40.0	2.0	0.0 - 6.0	0.5	0.0 - 3.0
						24.8	12.7				9.2			
3B	HOME	1	NF	1748	–	6.9	2.6	0.1 - 4.0	22.5	10.0 - 35.0	5.1	2.0 - 14.0	1.5	0.0 - 3.0
(TRIP SEQUENCES 2A-3A AND 2B-3B OCCUR IN EQUAL NUMBER)														

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

from the total distance and assigning that distance to trip 2B. Trip 3B is then assigned the remainder. The first two segment distances of trip 2B reverse those of the morning trip. The third segment is structured to reflect the distance to the shopping destination. Average speeds indicated and used in calculating the remaining results are those of the time slot, purpose, trip segment string shown. Momentary stops and idling time are allocated in a way consistent with the distance allocation. Start times for trips 3A and 3B were obtained by adding the mean elapsed time between trips for values under one hour to the mean arrival time at the shopping destination. The value added is 23 minutes. No range is shown for start time value obtained this way.

The Four-Trip Day

Figures 1-5 through 1-7 show the three trip-to-trip transition matrices for the four-trip day. Two typical patterns for the four-trip day were discovered. The first is distinguished by a pair of trips in the evening. The second by a pair of trips during the noon period.

Evening Pattern

Cell 26 in Figure 1-5 shows that 46 cars transitioned from time slot two to time slot six. Of these, 33 transitioned from a work trip to a home trip. We also note that 18 other cars transitioned to time slot six from time slots other than number two. Turning to Figure 1-6, we see that of the 64 cars that transitioned to time slot six, 61 in turn transitioned to third trips in time slots six and seven. Of these third trips in time slot six, seven were shopping trips, six were recreation. Third trips in time slot seven included nine shopping trips and 13 recreation trips. Figure 1-7 shows that these third trips in time slot six transitioned primarily to fourth trips in time slots six and seven. Of the 22 of these fourth trips in time slot six (cell 66), 14 were return trips from shopping. Of the 42 of these fourth trips in time slot seven (cells 67 and 77), 19 were return trips from shopping, 11 were return trips from recreation.

TO TIME SLOT

FROM TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	3	0	0	0	1	0	0
0600-0859		8	10	25 W-Lunch	16 W-H	46 W-H	2	0
0900-1129			2	3	0	0	0	0
1130-1329				0	1	0	0	0
1330-1629					5	10	0	0
1630-1829						7	2	0
1830-2059							3	1
2100-2359								0

TRIP ONE TO TRIP TWO

TOTAL FOUR-TRIP WEEKDAYS: 145

LEGEND

H - Home
W - Work
B - Business
S - Shopping
C - Church, School, etc.
R - Recreation

FIGURE 1-5

FOUR-TRIP WEEKDAY TRANSITION MATRIX

FROM TIME SLOT / TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	0	0	0	0	0	0	0
0600-0859		0	0	0	0	1	0	0
0900-1129			0	0	0	5	0	0
1130-1329				0	3	22 W-H	1	0
1330-1629					3	9	13	0
1630-1829						22 S-H	20 S,R-H	8
1830-2059							22 S,R-H	18 R-H
2100-2359								6

TRIP THREE TO TRIP FOUR

FOUR-TRIP WEEKDAY

LEGEND

H - Home
W - Work
B - Business
S - Shopping
C - Church, School, etc.
R - Recreation

FIGURE 1-7

FOUR-TRIP WEEKDAY TRANSITION MATRIX

From these data we deduce the typical Four-Trip Day (Evening) Pattern, shown in Table 1-5. Trip one is to work in time slot two. Trip two returns home in time slot six. Trip three is a shopping or recreation trip in time slot seven. Trip four returns home in the same time slot. Trips one and two are equally divided between the two trip segment structures used in the previous two patterns. The trip segment structures of the evening trips are both nonfreeway. Shopping trips and home trips in time slot seven show a negative correlation with the nonfreeway/freeway/nonfreeway trip segment string.

The minimum number of car-days that show the typical four-trip evening pattern (summing the shopping and recreation trips in time slot seven) is 18. This represents 12% of all four-trip days and 1.6% of all car-days in the survey.

Noon Pattern

Cell 24 in Figure 1-5 shows 25 cars transitioning from a trip in time slot two to a trip in time slot four. All of them transition from a first trip to work, 12 of them to a shopping trip, six to a business trip, and four to a recreation trip. Under the definition of trip purpose given to survey participants, any of these trips could be to lunch. In Figure 1-6, cell 44 shows 23 trip two's transitioning to trip three's in time slot four. Twenty-two of these are return trips to work, 12 from shopping, four from business, and three from recreation. Cell 46 of Figure 1-7 shows that 22 third trips in time slot four transition to a fourth trip in time slot six. Nineteen of these are from work to home. These data indicate the structure of the typical Four-Trip Day (Noon) Pattern. Trip one is to work, trip two to lunch, trip three back to work, and trip four home in the evening.

The noontime trips are both nonfreeway. The values in Table 1-6 are obtained by combining and weighting the computed values for the three purposes: business, shopping, and recreation. The morning work trip and the evening return home trip have the same structure as in the other typical patterns.

TABLE 1-5

THE TYPICAL FOUR-TRIP DAY (EVENING) PATTERN

(REPRESENTS 12% OF ALL FOUR-TRIP DAYS, 1.6% OF ALL CAR-DAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME		MEAN ELAPSED TIME (MIN)	DISTANCE (MILES)		AVERAGE SPEED (MPH)		NUMBER OF STOPS (IDLES)		IDLE TIME (MIN)	
				MEAN	RANGE*		MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**
1A	WORK	1	NF	0722	0645 - 0759	15.3	5.8	0.1 - 9.0	22.7	15.0 - 35.0	11.8	4.0 - 22.0	3.6	1.0 - 8.0
	OR:													
1B	WORK	1	NF	0712	0635 - 0749	8.9	4.2	0.1 - 6.0	28.3	15.0 - 45.0	4.3	2.0 - 12.0	1.3	0.0 - 2.0
		2	F			12.2	7.7	2.0 - 21.0	37.7	20.0 - 55.0	1.5	0.0 - 2.0	0.3	0.0 - 1.0
		3	NF			8.6	3.4	0.1 - 6.0	23.6	10.0 - 40.0	4.5	2.0 - 12.0	1.4	0.0 - 2.0
						29.7	15.3							
(TRIPS 1A AND 1B OCCUR IN EQUAL NUMBER)														
2A	HOME	1	NF	1722	1649 - 1755	15.5	5.8	0.1 - 9.0	22.5	10.0 - 35.0	10.5	4.0 - 22.0	2.9	1.0 - 6.0
	OR:													
2B	HOME	1	NF	1707	1634 - 1740	8.4	3.4	0.1 - 6.0	24.2	10.0 - 45.0	6.9	2.0 - 16.0	1.4	0.0 - 3.0
		2	F			12.4	7.7	2.0 - 21.0	37.1	20.0 - 60.0	2.3	0.0 - 3.0	0.4	0.0 - 1.0
		3	NF			10.7	4.2	0.1 - 6.0	23.6	10.0 - 40.0	4.9	2.0 - 12.0	1.9	0.0 - 3.0
						31.5	15.3							
(TRIPS 2A AND 2B OCCUR IN EQUAL NUMBER)														
3	SHOP OR REC.	1	NF	1934	1852 - 2015	7.8	2.9	0.1 - 6.0	22.3	10.0 - 30.0	5.6	0.0 - 8.0	1.8	0.0 - 2.0
4	HOME	1	NF	1941	1855 - 2027	7.8	3.0	0.1 - 6.0	23.2	10.0 - 30.0	4.6	0.0 - 8.0	1.6	0.0 - 2.0

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

TABLE 1-6

THE TYPICAL FOUR-TRIP DAY(NOON) PATTERN

(REPRESENTS 13% OF ALL FOUR-TRIP DAYS, 1.6% OF ALL CAR-DAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME MEAN	START TIME RANGE*	MEAN ELAPSED TIME (MIN)	DISTANCE (MILES) MEAN	DISTANCE (MILES) RANGE**	AVERAGE SPEED (MPH) MEAN	AVERAGE SPEED (MPH) RANGE**	NUMBER OF STOPS (IDLES) MEAN	NUMBER OF STOPS (IDLES) RANGE**	IDLE TIME (MIN) MEAN	IDLE TIME (MIN) RANGE**
1A	WORK	1	NF	0722	0645 - 0759	15.3	5.8	0.1 - 9.0	22.7	15.0 - 35.0	11.8	4.0 - 22.0	3.6	1.0 - 8.0
	OR:													
1B	WORK	1	NF	0712	0635 - 0749	8.9	4.2	0.1 - 6.0	28.3	15.0 - 45.0	4.3	2.0 - 12.0	1.3	0.0 - 2.0
		2	F			12.2	7.7	2.0 - 21.0	37.7	20.0 - 55.0	1.5	0.0 - 2.0	0.3	0.0 - 1.0
		3	NF			8.6	3.4	0.1 - 6.0	23.6	10.0 - 40.0	4.5	2.0 - 12.0	1.4	0.0 - 2.0
						29.7	15.3				10.3		3.0	
(TRIPS 1A AND 1B OCCUR IN EQUAL NUMBER)														
2	SHOP OR RECREATION (LUNCH)	1	NF	1216	1147 - 1245	6.8	2.2	0.1 - 6.0	19.5	10.0 - 25.0	6.3	2.0 - 10.0	2.0	0.0 - 4.0
3	WORK	1	NF	1241	1216 - 1306	6.2	2.2	0.1 - 6.0	21.2	10.0 - 30.0	5.3	2.0 - 6.0	1.6	0.0 - 2.0
4A	HOME	1	NF	1722	1649 - 1755	15.5	5.8	0.9 - 9.0	22.5	10.0 - 35.0	10.5	4.0 - 22.0	2.9	1.0 - 6.0
	OR:													
4B	HOME	1	NF	1707	1634 - 1740	8.4	3.4	0.1 - 6.0	24.2	10.0 - 45.0	6.5	2.0 - 16.0	1.4	0.0 - 3.0
		2	F			12.4	7.7	2.0 - 21.0	37.1	20.0 - 60.0	2.3	0.0 - 3.0	0.4	0.0 - 1.0
		3	NF			10.7	4.2	0.1 - 6.0	23.6	10.0 - 40.0	4.9	2.0 - 12.0	1.9	0.0 - 3.0
						31.5	15.3							
(TRIPS 2A AND 2B OCCUR IN EQUAL NUMBER)														

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

The minimum number of car-days that showed the Four-Trip Day (Noon) Pattern was 19. This number represents 13% of all four-trip days and 1.6% of all car-days in the sample.

The Five-Trip Day

Figures 1-8 through 1-11 contain the trip-to-trip transition matrices for the five-trip day. As noted earlier, as the number of trips per day increases the number of possible trip-to-trip combinations increases geometrically and the likelihood of detecting a typical pattern decreases. The matrices for the five-trip day require careful analysis of both time slot and purpose transitions to detect the pattern. In Figure 1-8, the modal transition is in cell 26 from work to home -- 15 out of 26 car-days. The matrix in Figure 1-9 showing trips two to three shows a modal transition in cell 66 with a typical purpose pair of home to shop -- but only 9 out of 24 car-days. Looking more closely at the adjacent cell, we find that seven out of 11 car-days also transition from home to shopping between trips two and three. In Figure 1-10, the modal transition is in cell 67, but the modal purpose transition is again from shopping to home. However, an examination of adjacent cells 66, 67, and 76 indicates that during these evening time slots, 16 out of a total of 60 cars transitioned from shopping to shopping. Then in Figure 1-11, the modal transition is in cell 77 where 21 out of 29 cars returned from shopping to home. From these indicators we derive the typical five-trip pattern shown in Table 1-7. Trip one to work in time slot two; trip two to home in time slot six; trip three to shop in time slot six; trip four, another shopping trip, in time slot seven; and finally, trip five, a trip home, also in time slot seven.

All evening trips in the typical trip patterns are nonfreeway trips. Trips one and two are the familiar work and home trips of the previous patterns.

The Five-Trip Day Pattern was carried out by at least 16 cars. These represented 16% of all five-trip days and 1.4% of all car-days.

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	3	2	1	0	0	0	0	0
0600-0859		11 W-B	8	9	11 W-H	26 W-H	2	0
0900-1129			2	4	0	1	0	0
1130-1329				3	0	0	0	0
1330-1629					4	5	1	0
1630-1829						4	2	0
1830-2059							0	0
2100-2359								0

TRIP ONE TO TRIP TWO

TOTAL FIVE-TRIP WEEKDAYS: 99

LEGEND

H - Home
W - Work
B - Business
S - Shopping
C - Church, School, etc.
R - Recreation

FIGURE 1-8

FIVE-DAY WEEKDAY TRANSITION MATRIX

TO TIME SLOT

FROM TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	1	1	0	1	0	0	0	0
0600-0859		2	2	2	2	3	0	0
0900-1129			4	5	0	1	1	0
1130-1329				9	4	2	1	0
1330-1629					2	12	3	0
1630-1829						24 H-S S-H	11 H-S	1
1830-2059							5	0
2100-2359								0

TRIP TWO TO TRIP THREE

FIVE-TRIP WEEKDAY

LEGEND

H - Home	S - Shopping
W - Work	C - Church, School, etc.
B - Business	R - Recreation

FIGURE 1-9

FIVE-TRIP WEEKDAY TRANSITION MATRIX

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	1	0	0	0	0	0	0
0600-0859		0	0	1	1	1	0	0
0900-1129			2	1	1	1	1	1
1130-1329				5	5	5	1	0
1330-1629					3	3	1	1
1630-1829						17 H-S S-S	24 H-S S-S	0
1830-2059							19 S-S	2
2100-2359								1

TRIP THREE TO TRIP FOUR

FIVE-TRIP WEEKDAY

LEGEND

H - Home
W - Work
B - Business
S - Shopping
C - Church, School, etc.
R - Recreation

FIGURE 1-10

FIVE-TRIP WEEKDAY TRANSITION MATRIX

FROM TIME SLOT / TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
0000-0559	0	0	0	0	0	0	0	0
0600-0859		0	0	0	0	1	0	0
0900-1129			0	1	0	1	0	0
1130-1329				2	0	3	2	0
1330-1629					3	5	2	0
1630-1829						10 S-H	14 S-H	4
1830-2059							29 S-H	17 S-H
2100-2359								5

TRIP FOUR TO TRIP FIVE
FIVE-TRIP WEEKDAY

LEGEND

H - Home
W - Work
B - Business
S - Shopping
C - Church, School, etc.
R - Recreation

FIGURE 1-11

FIVE-DAY WEEKDAY TRANSITION MATRIX

TABLE 1-7

THE TYPICAL FIVE-TRIP DAY PATTERN

(REPRESENTS 16% OF ALL FIVE-TRIP DAYS, 1.4% OF ALL CAR-DAYS)

TRIP NUMBER	PURPOSE	SEGMENT NUMBER	ROUTE TYPE	START TIME		MEAN ELAPSED TIME (MIN)	DISTANCE (MILES)		AVERAGE SPEED (MPH)		NUMBER OF STOPS (IDLES)		IDLE TIME (MIN)	
				MEAN	RANGE*		MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**	MEAN	RANGE**
1A	WORK	1	NF	0722	0645 - 0759	15.3	5.8	0.1 - 9.0	22.9	15.0 - 35.0	11.8	4.0 - 22.0	3.6	1.0 - 8.0
	OR:													
1B	WORK	1	NF	0712	0635 - 0749	8.9	4.2	0.1 - 6.0	28.3	15.0 - 45.0	4.3	2.0 - 12.0	0.3	0.0 - 2.0
		2	F			12.2	7.7	2.0 - 21.0	37.7	20.0 - 55.0	1.5	0.0 - 2.0	0.3	0.0 - 1.0
		3	NF			8.6	3.4	0.1 - 6.0	23.6	10.0 - 40.0	4.5	2.0 - 12.0	1.4	0.0 - 2.0
						29.7	15.3							
(TRIPS 1A AND 1B OCCUR IN EQUAL NUMBER)														
2A	HOME	1	NF	1722	1649 - 1755	15.5	5.8	0.9 - 9.0	22.5	10.0 - 35.0	10.5	4.0 - 22.0	2.9	1.0 - 6.0
	OR:													
2B	HOME	1	NF		1634 - 1740	8.4	3.4	0.1 - 6.0	24.2	10.0 - 45.0	6.9	2.0 - 16.0	1.4	0.0 - 3.0
		2	F			12.5	7.7	2.0 - 21.0	37.1	20.0 - 60.0	2.3	0.0 - 3.0	0.4	0.0 - 1.0
		3	NF			10.7	4.2	0.1 - 6.0	23.6	10.0 - 40.0	4.9	2.0 - 12.0	1.9	0.0 - 3.0
						31.5	15.3							
3	SHOP	1	NF	1830	--------	8.5	3.1	0.1 - 6.0	21.9	10.0 - 30.0	8.2	2.0 - 12.0	2.4	0.0 - 4.0
4	SHOP	1	NF	1934	1850 - 2016	6.5	2.3	0.1 - 6.0	21.1	10.0 - 35.0	5.0	0.0 - 8.0	1.7	0.0 - 3.0
5	HOME	1	NF	2026	--------	7.8	3.0	0.1 - 6.0	23.2	10.0 - 40.0	4.6	0.0 - 8.0	1.6	0.0 - 2.0

* RANGE EQUALS MEAN PLUS OR MINUS ONE STANDARD DEVIATION

** RANGE CONTAINS AT LEAST 75% OF ALL CASES (SEE TEXT)

GENERAL RESULTS

This section contains a discussion of additional results of the study including a description of the sample, an analysis of daily variations in the data, and an analysis of the individual trip and segment variables as they are affected by such factors as time of day, trip purpose, and type of route used.

The Los Angeles Samples

During the Los Angeles Survey, SDC installed Tachographs in 199 automobiles. For various reasons, described more fully in Part II of the report, data from 30 of these installations were unusable. The results of this study, then, are based on data from 169 automobiles driven in the greater Los Angeles metropolitan area during the period June 18, 1968 to August 6, 1968. A total of 1042 car-days are included in the sample. Participants took 4901 trips during the survey and covered more than 37,000 miles. The average daily distance driven by participants was 36 miles, this during an average of 4.7 trips per day, which required an average of one hour and sixteen minutes per day of driving.

Sample Biases

As discussed in Part II of the report, the method used in selecting survey participants biased the sample toward working members of the overall population. In view of this bias, SDC expected that work-related trips would constitute a major component of the resultant typical trip patterns described in the previous section. There is no doubt in our minds that such work-related utilization represents a major, if not the major, component of the overall utilization pattern in the Los Angeles urban area. The sample was made up of participants from all levels of the corporate structure within the participating firms, and the firms represented a reasonable cross-section, in terms of size, of all firms in the area. The results of the survey, therefore, represent a good cross-section of driving behavior within the industrial and commercial sector of the community.

The logistics involved in installing Tachographs in the survey cars required a correction in the survey results to compensate for inconsistencies in the data. The instruments were installed during the morning and afternoon of the first survey day for each car. They were removed during the morning of the eighth day. As a result, the data collected during each car's week represented eight calendar days, but the first and eighth days each contained only about a half-day's worth of data. In order to remove this "half-day" bias which would certainly affect the daily pattern of automobile usage reflected in the results of the survey, data from the last half of the first day and from the first half of the eighth day were combined during the data reduction process. In no case was there an overlap of trips on the two combined days that would cause the loss of a trip in the final results. In some cases, however, data from one of the two days was unusable for one reason or another (failure of the Tachograph, errors in the recorded data, etc.). In these cases, the daily records of the usable half-day were specially tagged and were removed from the analysis of daily patterns. Because their half-day nature would have no effect on the analysis of trip variables, these records were used in that portion of the study.

Data Collected

The Tachograph instrument provided data indicating the day of the survey, trip and trip segment[1] start times and complete times, trip and segment distance traveled, length of periods of idling time in excess of 40 seconds, number of momentary stops, and type of road (freeway, nonfreeway) driven on for each segment. Information contained in the log book kept by the driver indicated the date, the purpose of each trip, geographic zone within which each trip started, type of location from which each trip started, road conditions, driver sex and age, whether the car was parked indoors or out at the end of each trip, and the fuel gauge reading at the start of each day. To these data we added various identifying and categorizing variables during the data reduction process so that the final record on each trip contains at least 54 separate data items.

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[1] A trip segment is defined as that portion of a trip driven over a single type of road, either freeway or nonfreeway.

Daily Patterns

Two classifications of the survey data were made in the analysis. First, data were segregated into two groups by weekday and weekend day. The latter included only Saturday and Sunday[1]. Second, the data were segregated into seven groups by day of the week. The latter was done at the request of CRC[2] to enable an examination of any daily variation that may occur.

The data base for the Los Angeles survey contains 792 active car-weekdays and 250 active car-weekend days. To these sums must be added zero-trip days that occurred but are not contained in the data base: 37 car-weekdays and 69 car-weekend days. The resulting totals are 829 car-weekdays and 319 car-weekend days. Table 1-8 shows the daily breakdown of the sample into active and inactive car days.

TABLE 1-8

DAILY SAMPLE SIZE IN CAR-DAYS

DAY	NUMBER OF CAR-DAYS IN SAMPLE		
	ACTIVE	INACTIVE (0-TRIP)	TOTAL
MONDAY	157	12	169
TUESDAY	157	7	164
WEDNESDAY	156	7	163
THURSDAY	157	9	166
FRIDAY	156	8	164
SATURDAY	132	28	160
SUNDAY	118	41	159

---

[1] Independence day fell on a Thursday, early in the survey period. It was treated as a weekday in the study as was the following Friday, even though many survey participants had a long weekend holiday.

[2] CRC-APRAC Project Groups CAPE-5 and CAPE-10

During the survey period, participants drove 4901 trips. These were divided into 3649 weekday trips and 1252 weekend trips. Tables 1-9 and 1-10 show the daily distribution by time slot of these trips as well as the weekday and weekend total distributions. Figure 1-12 presents a more detailed time distribution of weekday trip start times by half-hour intervals. Figure 1-13 presents similar data for weekend trip start times.

TABLE 1-9

TIME DISTRIBUTION OF WEEKDAY TRIPS BY DAY AND TIME SLOT

DAY	TIME SLOT								
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	DAILY TOTAL
MONDAY	18	150	40	69	72	190	133	28	700
TUESDAY	11	163	62	68	84	182	123	45	738
WEDNESDAY	14	149	52	77	90	178	106	50	716
THURSDAY	16	131	50	88	103	158	107	52	705
FRIDAY	8	159	50	99	97	205	115	57	790
WEEKDAY TOTAL	67	752	254	401	446	913	584	232	3649

TABLE 1-10

TIME DISTRIBUTION OF WEEKEND TRIPS BY DAY AND TIME SLOT

DAY	TIME SLOT						
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	DAILY TOTAL
SATURDAY	43	115	127	255	119	40	699
SUNDAY	46	60	109	194	100	44	553
WEEKEND TOTAL	89	175	236	449	219	84	1252

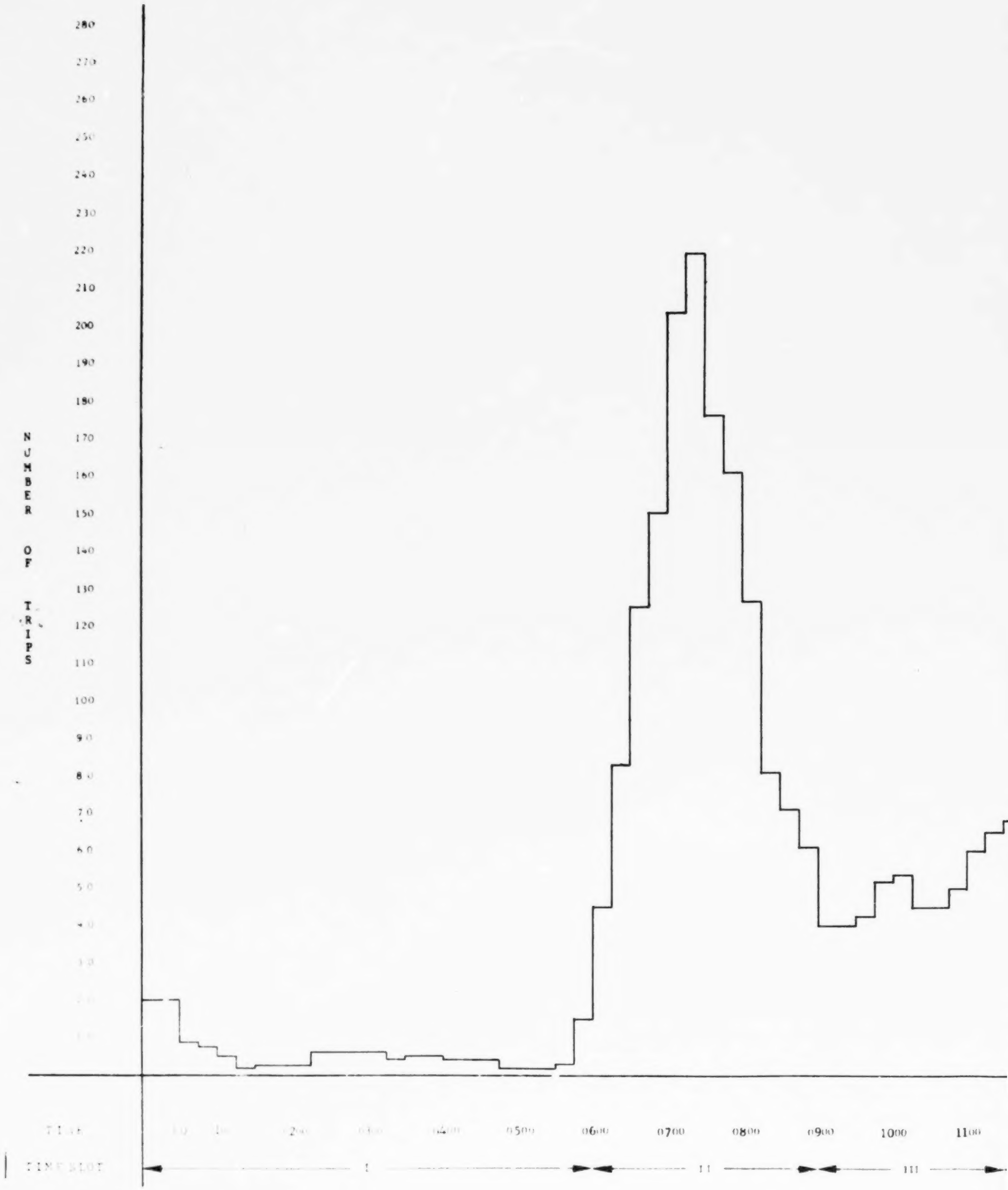
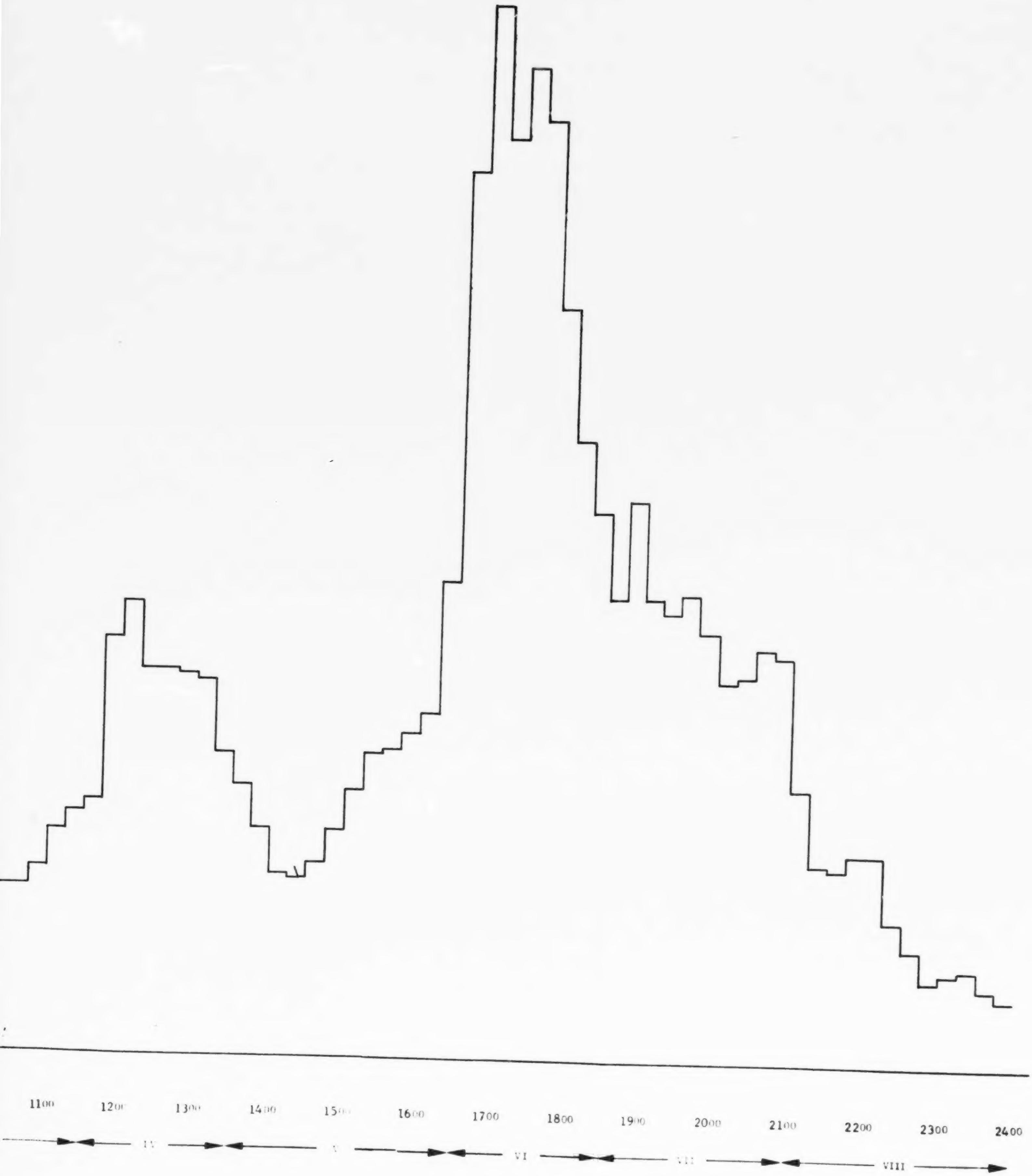


FIGURE 1-12

DISTRIBUTION OF WEEKDAY TRIP START TIMES

1A


1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
IV
V
VI
VII
VIII

a

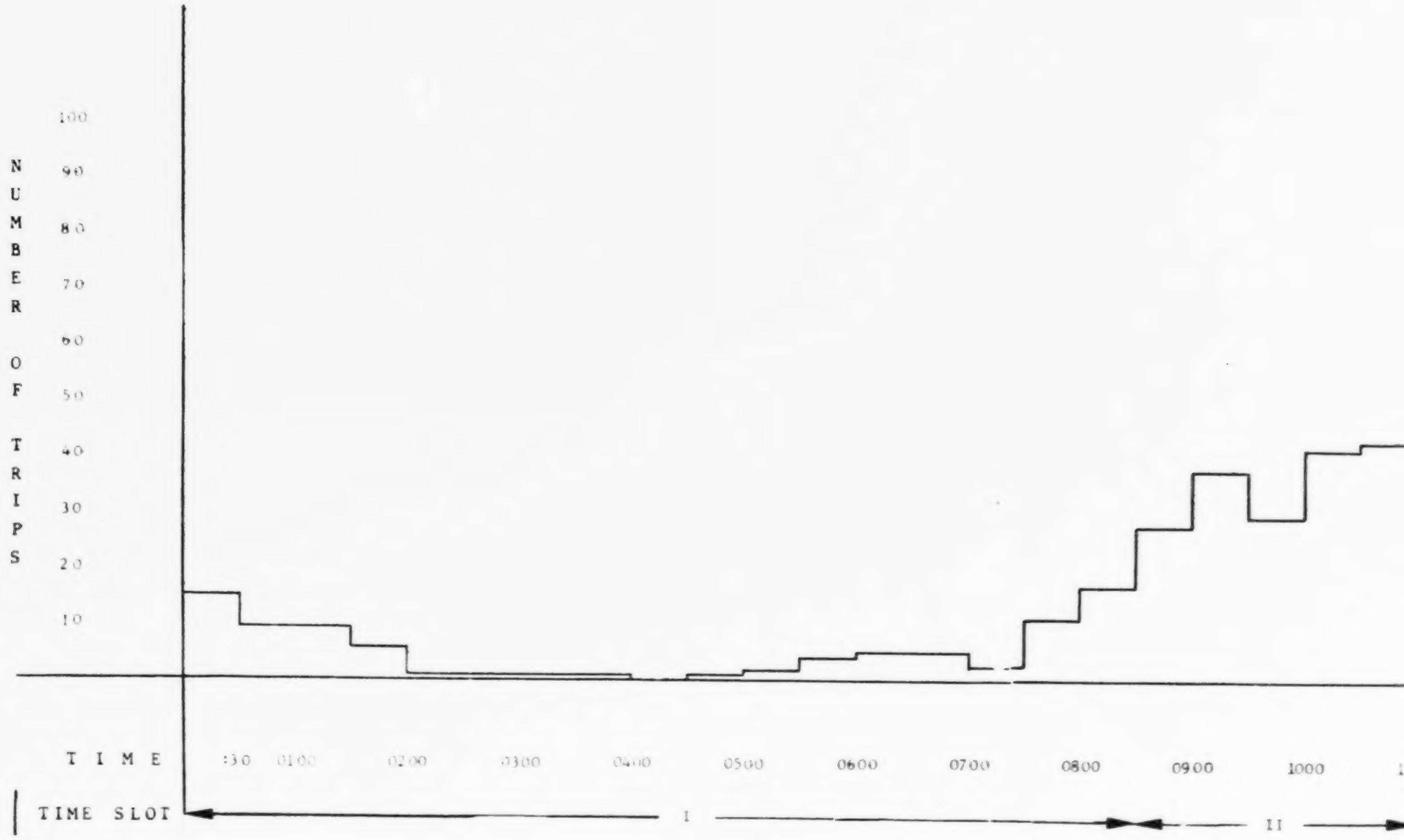
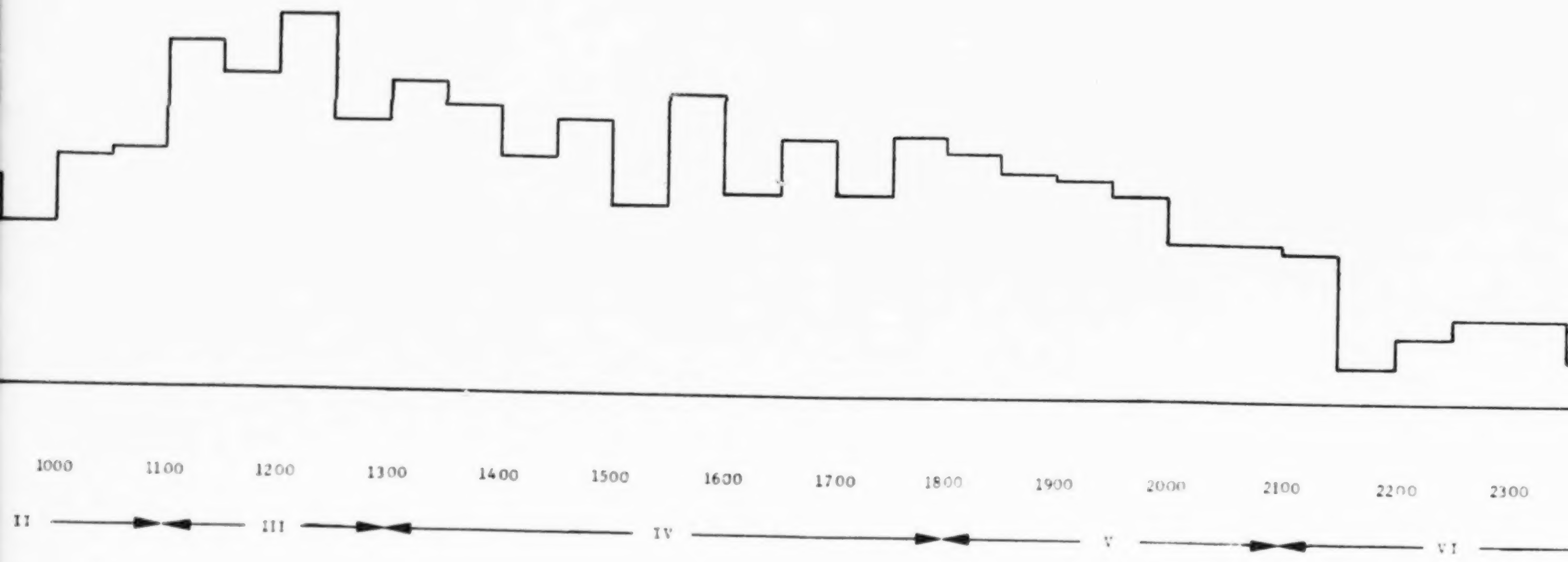


FIGURE 1-13

DISTRIBUTION OF WEEKEND TRIP START TIMES

01A


1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
II
III
IV
V
VI

a

Trip generation rates for weekday trips are 4.61 trips per day driven (i.e., including only those days on which trips were actually taken) and 4.40 trips per day for all days (i.e., including zero-trip days). On weekends, these rates are 5.01 and 3.92 trips per day respectively. The difference reflects the greater likelihood of a zero-trip day on a Saturday or Sunday.

An analytical tool that assisted greatly in determining trip pattern relationships is the trip-to-trip transition matrix. It is a tableau showing the incidence of various trip related dependencies between successive trips. In order to examine weekday-weekend and daily variations, summary two-step, trip-to-trip transition matrices were assembled for all trips. Figures 1-14 and 1-15 are simplified versions of these matrices. The weekday matrix of which only the upper right-hand triangle is shown, is divided into nine rows and eight columns. Rows two through nine and columns one through eight correspond to the eight weekday time slots. The first row is called the zero row and corresponds to any time slot on the previous day. A trip in the $j^{\underline{th}}$ time slot of any weekday that was preceded by a trip in the $i^{\underline{th}}$ time slot is tabulated in cell ij where i denotes the row and j denotes the column of the transition matrix. If a previous trip took place on the preceding day, the trip is tabulated in zero row in the column appropriate to its own time slot. In the original matrix, the purpose-to-purpose transition is also shown. We have simplified the matrix in Figure 1-14 by showing only the modal or typical purpose pattern(s) in cells that have high frequency counts. Figure 1-15 shows the matrix for weekend trips. This matrix is a seven by six matrix due to the reduced number of time slots on weekdays.

Figures 1-24 to 1-30 at the end of this part show the daily two-step, trip-to-trip transition matrices. These are included to provide assistance to further analysis of daily differences by the reader.

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
PREVIOUS DAY	37	620 H-W	35	11	15	17	8	1
0000-0559	23	24	7	3	0	2	1	0
0600-0859		113	87	93	74	235 W-S W-H	15	2
0900-1129			124 B-B	90	18	26	4	3
1130-1329				183 S-W*	106	89	10	1
1330-1629					214 B-B	239 W-H	29	5
1630-1829						317 S-H H-S	277 H-S H-R S-H	35
1830-2059							248 S-H S-S R-H	120 R-H
2100-2359								68

WEEKDAY

TOTAL TRIPS: 3629

* HIGH PROBABILITY THESE ARE TRIPS TO AND FROM LUNCH

LEGEND

H - Home
W - Work
B - Business
S - Shopping
C - Church, School, etc.
R - Recreation

FIGURE 1-15

TWO-STEP TRIP-TO-TRIP TRANSITION MATRIX, ALL WEEKEND TRIPS

FROM TIME SLOT \ TO TIME SLOT	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359
PREVIOUS DAY	65	77	46	54	5	2
0000-0829	20	25	13	20	4	1
0830-1059		74	60	24	4	1
1100-1259			114 S-H S-S	94 S-H	6	1
1300-1759				253 S-S S-H R-R	108 H-R R-H	12
1800-2059					96 S-H	48
2100-2359						21

WEEKEND

TOTAL TRIPS: 1248

LEGEND

H - Home
W - Work
B - Business
S - Shopping
C - Church, School, etc.
R - Recreation

FIGURE 1-15

TWO-STEP TRIP-TO-TRIP

TRANSITION MATRIX, ALL WEEKEND TRIPS

In all these matrices, the purpose-to-purpose transitions tabulated are those that clearly stand out. In some instances of high frequency cell counts, most notably those in the Sunday matrix (Figure 1-30), no purpose-to-purpose transition stands out as typical. This indicates a substantial independence between purpose of trip and the time it is taken. With respect to Sunday travel, this independence is borne out by further analysis discussed below.

A final analytical tool used to evaluate daily variation in trip patterns is a two-way contingency table showing the incidence of particular trip purpose and trip segment string combinations in each time slot. These tables were prepared for weekday, weekend, and daily breakdowns of the data. Chi-square tableaux were prepared for each of these tables to see which purpose stood out as typical for each time slot. In these tableaux, an "expected" frequency count is compiled for each cell by reallocating each column total over the cells in that column in proportion to the row totals. The assumption behind this computation is that row and column effects do not interact to affect the cell totals. In the case at hand, it is clear that these effects do interact (e.g., there is more likelihood of a go-to-work trip being taken in time slot two than in time slot eight). Because there is interaction, the differences between the actual cell counts and the "expected" cell counts obtained by computation indicate which purpose or trip segment string (row) is typical of the time slot. Tables 1-11 and 1-12 show the purpose-time slot contingency tables for weekday and weekend trips. "Expected" frequency counts for each cell are shown in italics below the actual frequency counts. Within the frequency table, the characteristic purpose(s) for each time slot is indicated by underlining the cell count we consider typical. The difficulty in selecting typical purposes is indicated in the weekend matrix where no trip purpose stands out both in terms of its absolute frequency (i.e., is a mode)

TABLE 1-11

ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP PURPOSE
BY TIME SLOT FOR WEEKDAY TRIPS
CHARACTERISTIC TIME SLOT PURPOSES UNDERLINED

TIME SLOT / PURPOSE	I 0000-0559	II 0600-0859	III 0900-1129	IV 1130-1329	V 1330-1629	VI 1630-1829	VII 1830-2059	VIII 2100-2359	TOTALS
GO HOME	34 *21*	20 *232*	21 *78*	48 *124*	126 *138*	508 *282*	226 *180*	143 *72*	1126
GO TO WORK	7 *16*	605 *185*	54 *63*	117 *99*	74 *110*	31 *225*	11 *144*	1 *57*	900
BUSINESS	3 *8*	46 *90*	121 *30*	97 *48*	115 *54*	31 *110*	16 *70*	19 *28*	438
SHOP	7 *14*	50 *153*	39 *52*	117 *82*	99 *91*	228 *186*	176 *119*	26 *47*	742
SCHOOL	0 *1*	3 *7*	4 *2*	0 *4*	1 *4*	11 *8*	13 *5*	0 *2*	32
RECREATION	16 *8*	28 *85*	15 *29*	22 *45*	31 *50*	104 *103*	142 *66*	53 *26*	411
TOTALS	67	752	254	401	446	913	584	232	3649

ACTUAL FREQUENCY
"EXPECTED" FREQUENCY (IN ITALICS)

TABLE 1-12

ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP PURPOSE
BY TIME SLOT FOR WEEKEND TRIPS
CHARACTERISTIC TIME SLOT PURPOSES UNDERLINED

TIME SLOT / PURPOSE	I 0000-0829	II 0830-1059	III 1100-1259	IV 1300-1759	V 1800-2059	IV 2100-2359	TOTALS
GO HOME	$\underline{36}$ *32*	36 *62*	80 *84*	144 *159*	$\underline{84}$ *78*	$\underline{49}$ *30*	429
GO TO WORK	12 *3*	12 *5*	4 *7*	7 *14*	3 *7*	0 *2*	38
BUSINESS	3 *1*	1 *3*	6 *4*	6 *7*	4 *4*	0 *1*	20
SHOPPING	16 *29*	$\underline{79}$ *58*	$\underline{90}$ *77*	$\underline{163}$ *147*	52 *72*	9 *27*	409
SCHOOL	3 *1*	9 *2*	1 *3*	3 *6*	0 *3*	0 *1*	16
RECREATION	19 *24*	38 *48*	55 *64*	$\underline{126}$ *122*	$\underline{76}$ *60*	26 *23*	340
TOTALS	89	175	236	449	219	84	1252

ACTUAL FREQUENCY
"EXPECTED" FREQUENCY

and the difference between its actual and "expected" frequency. Therefore, the best measure of a typical purpose would be its absolute frequency. Tables 1-32 through 1-38, also at the end of this part, contain purpose-time slot contingency tables for the daily records. These tables also contain the daily trip segment string-time slot tables discussed below. Again, these are included to enable the reader to carry out further analysis of daily differences.

An analysis of the individual weekday tables compared to the total weekday table in terms of percentage was carried out using the chi-square test. The purpose of the analysis was to detect any significant daily variation in the time slot distribution of trips or in the purpose distribution. The significance level of 0.95 was used. Results of the test showed only two significant differences between individual days and the weekday totals. The time distribution of Monday trips was significantly different than the time distribution of all weekday trips, the major difference being a higher proportion of trips in the periods 1630-1829 and 1830-2059 than occurs in the weekday total. The purpose distribution of Friday trips was also significantly different than the weekday total. Here the difference was accentuated by a greater number of shopping and recreation trips than would be expected and a consequent decrease in return trips to home.

The time slot distribution of trip segment string is shown in Table 1-13 for weekday trips and in Table 1-14 for weekend trips. "Expected" frequencies are again shown in italics. The weekday figures indicate an interesting concentration of freeway utilization in the morning hours when compared to the "expectations." The disparity between actual and "expected" frequencies does not recur during the evening rush hour even though there are similarily large numbers of trips that use freeways. No doubt this is indicative of the high likelihood that a trip to or from work will use freeways for part of its completion. During the morning hours, especially in time slot two,

TABLE 1-13

ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP SEGMENT STRING BY TIME SLOT FOR WEEKDAYS

TRIP SEGMENT STRING	TIME SLOT								TOTALS
	0000-0559	0600-0859	0800-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
N	37 *46*	373 *512*	164 *173*	322 *273*	311 *304*	612 *622*	484 *404*	181 *158*	2484
NFN	26 *19*	337 *216*	83 *73*	75 *115*	121 *128*	268 *262*	89 *168*	48 *67*	1047
NFNFN	2 *1*	30 *16*	4 *5*	3 *8*	8 *9*	23 *19*	5 *12*	1 *5*	76
OTHER	2 *1*	12 *9*	3 *3*	1 *5*	6 *5*	10 *10*	6 *7*	2 *3*	42
TOTALS	67	752	254	401	446	913	584	232	3649

ACTUAL FREQUENCY

"EXPECTED" FREQUENCY

N = NONFREEWAY SEGMENT

F = FREEWAY SEGMENT

TABLE 1-14

ACTUAL AND "EXPECTED" FREQUENCIES OF TRIP SEGMENT STRING BY TIME SLOT FOR WEEKENDS

TRIP SEGMENT STRING	TIME SLOT						TOTALS
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
N	55 *72*	152 *142*	201 *192*	375 *365*	178 *178*	56 *68*	1017
NFN	33 *15*	19 *30*	29 *40*	64 *76*	39 *37*	27 *14*	211
NFNFN	1 *1*	3 *2*	3 *3*	6 *5*	1 *3*	1 *1*	15
OTHER	0 *1*	1 *1*	3 *2*	4 *3*	1 *1*	0 *1*	9
TOTALS	89	175	236	449	219	84	1252

trips to work constitute such a major portion of all traffic that anything characteristic of them will dominate the statistics of the period. On weekends the use of freeways is considerably diminished both in frequency and in comparison between actual and "expected" frequency in all but the first time slot.

Tables 1-32 through 1-38 at the end of this part also contain daily trip segment string-time slot tables. A comparison of the daily frequencies to the weekly total for weekdays showed no significant variation in the distribution of trip segment string between the days.

Trip Descriptors

The discussion of general results so far has dealt with the incidence of variables that can only be counted. These variables essentially define cases under which we wish to examine the behavior of such trip descriptive variables as distance, elapsed time, velocity, number of stops with engine on and off, and idling time. The present section is devoted to a detailed examination of these variables.

It will be noted that in the tabular presentations of data that follow the number of cases tabulated for each trip descriptor varies. This variance is because outlying cases had to be discarded in order to meet computer storage limitations or because they were deemed unrealistic.[1] In all cases the number of outlying cases was less than one percent of the data and would have little or no effect on the results. This requirement to discard data, combined with the use of class intervals for analytical purposes, means that the data on distance, elapsed time and average speed will not necessarily be functionally related in each set of cases.

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[1] See discussion in Part III of this problem

Trip and Segment Distance

The average distance per trip driven during the survey was 7.60 miles. This number is deceptive, however. The distribution of trip distances understandably shows a wide range as is indicated in Figure 1-16, Distribution of Weekday Trip Distance, and in Figure 1-17, Distribution of Weekend Trip Distance. Of more particular interest is the time distribution of distance with respect to trip segment string. Tables 1-15 and 1-16 show the time slot distribution of number of trips by trip segment string for weekday and weekend respectively along with the average trip distance for each type of trip during the time slot. Table 1-17 shows the distribution of segment distance by time slot for nonfreeway and freeway segments associated with freeway trips on weekdays. These data were not processed for weekend trips due to computer time limitations.

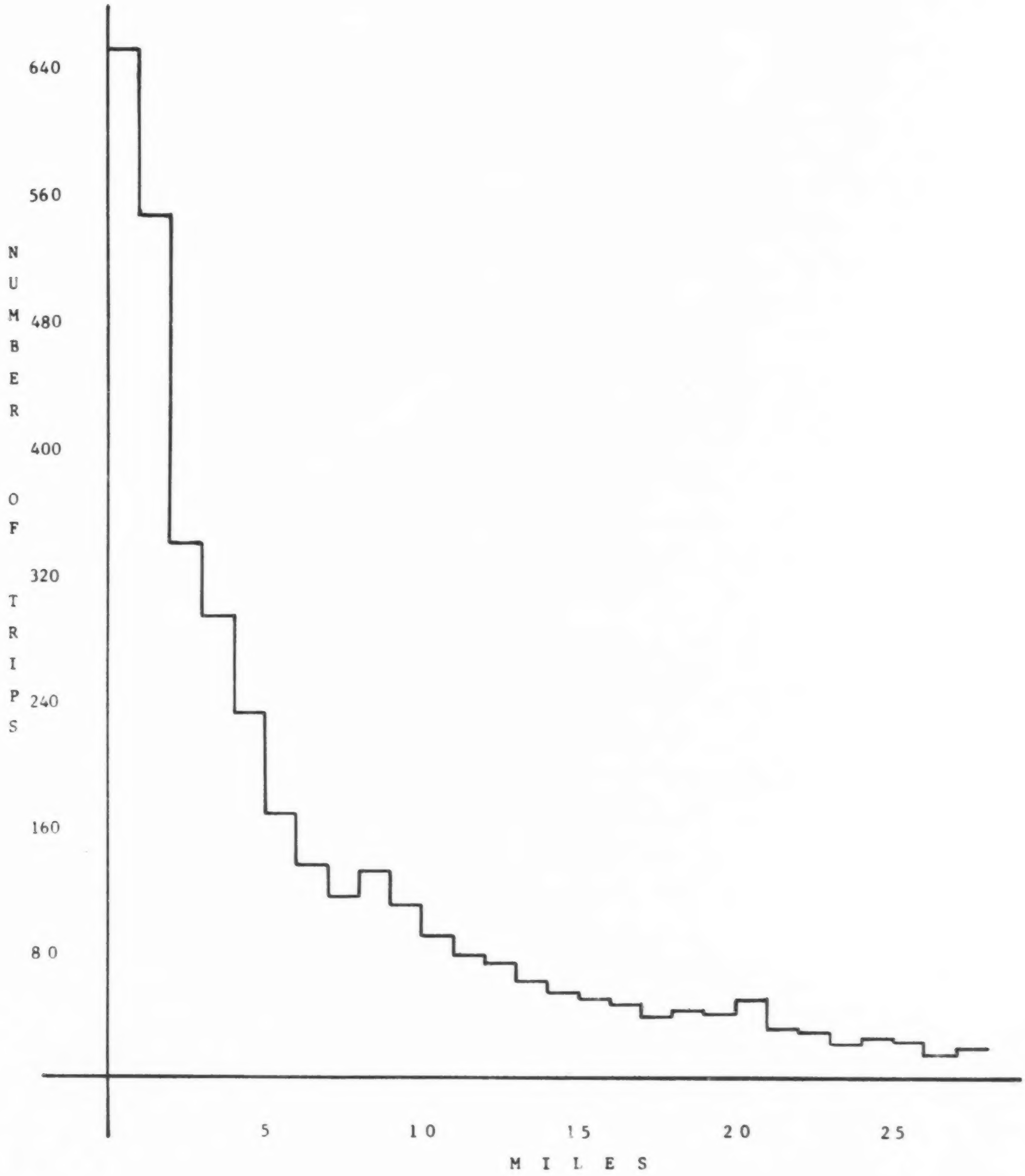

FIGURE 1-16

DISTRIBUTION OF TRIP DISTANCE, WEEKDAY TRIPS

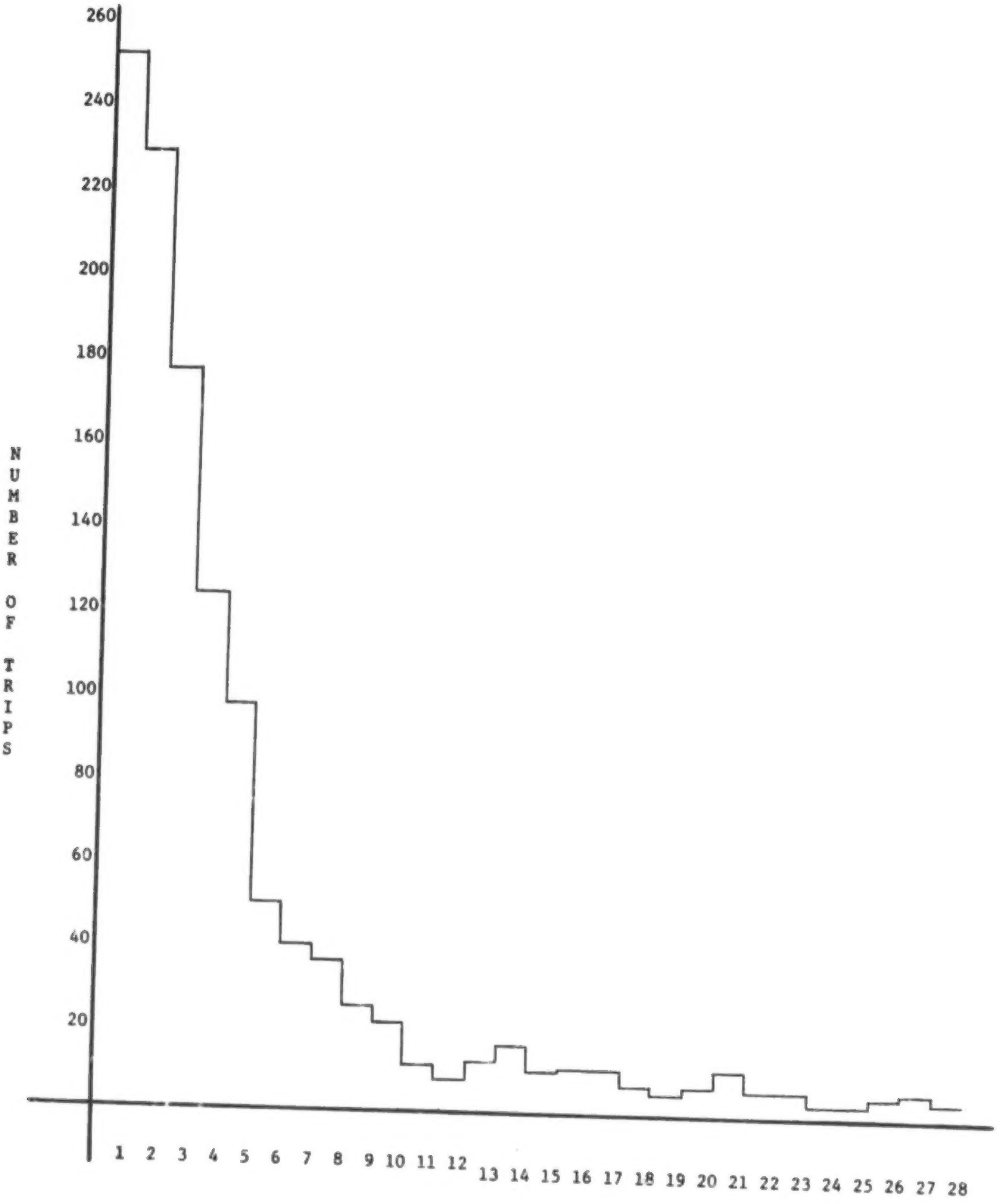

FIGURE 1-17

DISTRIBUTION OF TRIP DISTANCE, WEEKEND TRIPS

TABLE 1-15

DISTRIBUTION OF WEEKDAY TRIPS BY TRIP SEGMENT STRING SHOWING AVERAGE DISTANCE PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
N: NUMBER OF CASES	37	373	164	322	311	612	484	181	2484
MEAN DISTANCE (MI.)	4.4	5.1	3.0	2.4	2.9	4.0	2.9	3.1	3.5
NFN: NUMBER OF CASES	25	334	82	75	119	264	87	47	1033
MEAN DISTANCE	16.8	15.6	15.4	13.5	14.5	15.5	14.0	15.2	15.1
NFNFN: NUMBER OF CASES	1	29	4	2	8	22	4	1	71
MEAN DISTANCE	31.5	24.2	14.0	23.5	20.2	20.9	16.0	26.5	21.8
OTHER: NUMBER OF CASES	2	11	3	1	5	10	6	2	40
MEAN DISTANCE	7.5	8.6	28.5	18.5	6.3	13.7	9.8	4.5	11.2
TOTAL: NUMBER OF CASES	65	747	253	400	443	908	581	231	3628
MEAN DISTANCE	9.6	10.6	7.5	4.6	6.4	7.9	4.7	5.7	7.3

TABLE 1-16

DISTRIBUTION OF WEEKEND TRIPS BY TRIP SEGMENT STRING SHOWING AVERAGE DISTANCE PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
N: NUMBER OF CASES	55	152	201	374	178	56	1016
MEAN DISTANCE (MI.)	4.5	2.4	3.1	3.4	2.9	3.8	3.2
NFN: NUMBER OF CASES	33	16	27	60	36	26	198
MEAN DISTANCE	14.5	17.2	17.2	15.8	16.8	20.4	16.7
NFNFN: NUMBER OF CASES	0	3	3	3	1	1	11
MEAN DISTANCE	-	26.2	26.5	15.2	25.5	13.5	22.0
OTHER: NUMBER OF CASES	0	1	1	3	0	0	5
MEAN DISTANCE	-	4.5	4.5	3.8	-	-	4.1
TOTAL: NUMBER OF CASES	88	172	232	440	215	83	1230
MEAN DISTANCE	8.2	4.2	5.1	5.1	5.4	9.1	5.5

TABLE 1-17

DISTANCE FOR SEGMENTS OF WEEKDAY FREEWAY TRIPS BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT							TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
NONFREEWAY[1]									
NUMBER OF CASES AVERAGE DISTANCE	54 4.4	763 3.9	189 3.1	166 3.1	246 3.1	629 3.2	277 3.3	106 7.8	2380 3.6
FREEWAY									
NUMBER OF CASES AVERAGE DISTANCE	28 13.8	407 7.9	97 10.8	81 6.9	128 9.1	338 9.0	115 10.8	61 10.1	1255 9.0
TOTAL									
NUMBER OF CASES AVERAGE DISTANCE	82 7.6	1170 5.3	286 5.7	247 4.4	374 5.1	967 5.2	342 5.8	167 8.6	3635 5.5

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS (I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

The data in Figures 1-16 and 1-17 are arbitrarily cut off above 28 miles. Nevertheless, these figures account for 96.3% of all weekday trips and 97.1% of all weekend trips. The large number of short trips, over 2200 weekday and 880 weekend trips of five miles or less, is somewhat startling to the authors. That most trips taken in the Los Angeles are so short in length may be a unique characteristic of this society that is so closely tied to the automobile. Comparisons with data from subsequent cities will indicate whether or not this is so.

Trip and Segment Velocity

The distribution of trip velocity, as shown in Figure 1-18 for weekdays and in Figure 1-19 for weekends is unimodal in both cases (i.e., single-peaked). The weekend distribution is, however, slightly more spread as indicated by its larger standard deviation, 12.3 versus 11.2 for weekday trips. The means are almost identical, 24.8 miles per hour for weekday trips and 24.6 miles per hour for weekend trips. Again, the time and trip segment string distribution points out greater differences. Tables 1-18 and 1-19 are analogous to the previous tabular presentation on trip distance. One notices increased average velocities on all freeway associated trips as compared to the nonfreeway trips. But the degree of increase varies with time slot and in time slot six, the evening rush hour, the difference becomes slight indeed. On the other hand, during the morning rush hour, when traffic is so overwhelmingly devoted to home-to-work trips, freeway travel appears to offer a greater advantage in terms of average speed.

Table 1-20 provides average velocity information on freeway and freeway segments associated with freeway trips by time slot for weekdays. As with the distance data, this computer run was not made for weekend trips.

Trip and Segment Elapsed Time

The distributions of elapsed time for weekday and weekend trips are shown in Figures 1-20 and 1-21 respectively. The mean for weekday trips is 16.3 minutes, for weekend trips it is 12.9 minutes. The weekday distribution indicates that 90% of all trips on these days are completed within 38 minutes. On weekends, this figure drops to 30 minutes.

Tables 1-21 and 1-22 show the mean elapsed time by time slot and trip segment string. The dependency of elapsed time on the complexity of the trip segment structure stands out clearly. Table 1-23 presents mean segment elapsed times for trips involving the use of freeways. The large number of short trip times is obviously related to the similar prevalence of short trip distances discussed previously.

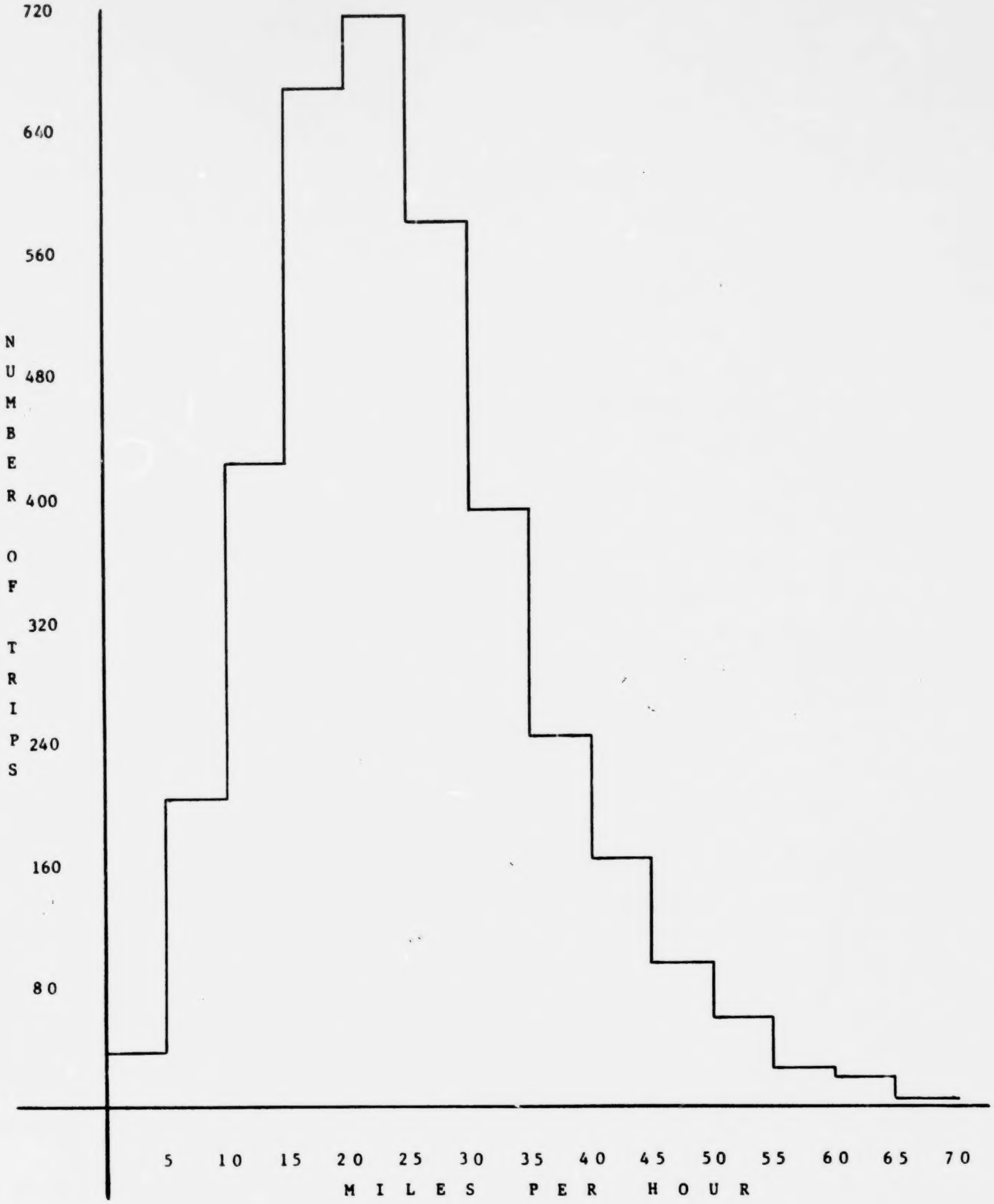

FIGURE 1-18

DISTRIBUTION OF AVERAGE SPEED, WEEKDAY TRIPS

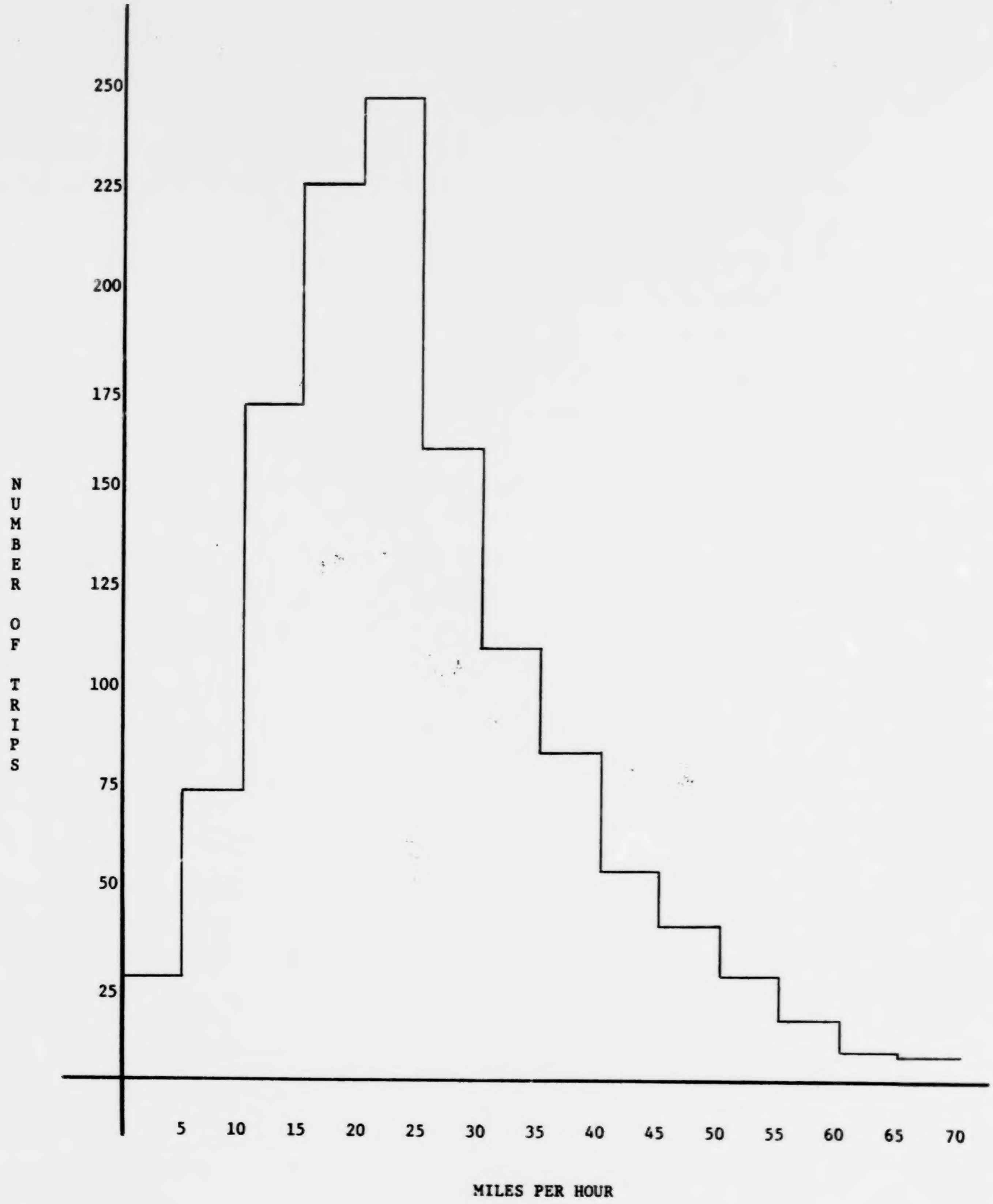

FIGURE 1-19

DISTRIBUTION OF AVERAGE SPEED, WEEKEND TRIPS

TABLE 1-18

DISTRIBUTION OF WEEKDAY TRIPS BY TRIP SEGMENT STRING
SHOWING AVERAGE SPEED IN MILES PER HOUR PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
N: NUMBER OF CASES	36	371	164	319	308	606	478	178	2460
AVERAGE SPEED (MPH)	22.4	22.1	20.8	20.7	18.7	22.0	22.6	18.1	21.2
NFN: NUMBER OF CASES	26	337	81	75	121	265	88	48	1041
AVERAGE SPEED	35.0	31.5	37.0	34.8	31.1	29.6	37.1	33.4	32.3
NFNFN: NUMBER OF CASES	2	30	4	3	8	23	5	1	76
AVERAGE SPEED	35.0	32.3	30.0	45.8	25.6	32.1	42.5	22.5	32.6
OTHER: NUMBER OF CASES	2	12	3	1	6	10	6	2	42
AVERAGE SPEED	42.5	34.5	47.5	22.5	35.8	32.0	33.3	30.0	34.7
TOTAL: NUMBER OF CASES	66	750	252	398	443	904	577	229	3619
AVERAGE SPEED	28.3	26.9	26.5	23.6	22.4	24.6	25.2	21.4	24.8

TABLE 1-19

DISTRIBUTION OF WEEKEND TRIPS BY TRIP SEGMENT STRING
SHOWING AVERAGE SPEED IN MILES PER HOUR PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
N: NUMBER OF CASES	55	150	199	372	174	54	1004
AVERAGE SPEED (MPH)	22.4	20.4	21.6	21.5	23.8	23.8	21.9
NFN: NUMBER OF CASES	33	19	29	64	38	27	210
AVERAGE SPEED	34.3	39.3	35.8	33.9	38.4	36.9	35.9
NFNFN: NUMBER OF CASES	1	3	3	6	1	1	15
AVERAGE SPEED	47.5	40.8	30.8	36.7	27.5	27.5	35.8
OTHER: NUMBER OF CASES	0	1	3	4	1	0	9
AVERAGE SPEED	0	37.5	44.1	33.8	37.5	0	38.1
TOTAL: NUMBER OF CASES	89	173	234	446	214	82	1238
AVERAGE SPEED	27.1	22.9	23.8	23.6	26.5	28.2	26.4

TABLE 1-20

AVERAGE SPEED FOR SEGMENTS OF WEEKDAY FREEWAY TRIPS BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630 1829	1830 2059	2100-2359	
NONFREEWAY[1]									
NUMBER OF CASES	55	765	189	169	249	635	233	109	2404
AVERAGE SPEED	31.1	26.5	26.7	28.0	26.0	24.8	30.8	26.7	26.6
FREEWAY									
NUMBER OF CASES	28	407	97	81	128	338	115	61	1255
AVERAGE SPEED	41.5	38.2	45.1	42.4	40.0	36.7	45.8	41.0	39.7
TOTAL									
NUMBER OF CASES	83	1172	286	250	377	973	348	170	3659
AVERAGE SPEED	34.6	30.6	32.9	32.6	30.8	28.9	35.8	31.8	31.1

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS (I.E., TRIP WITH N-TRIP SEGMENT SEQUENCE)

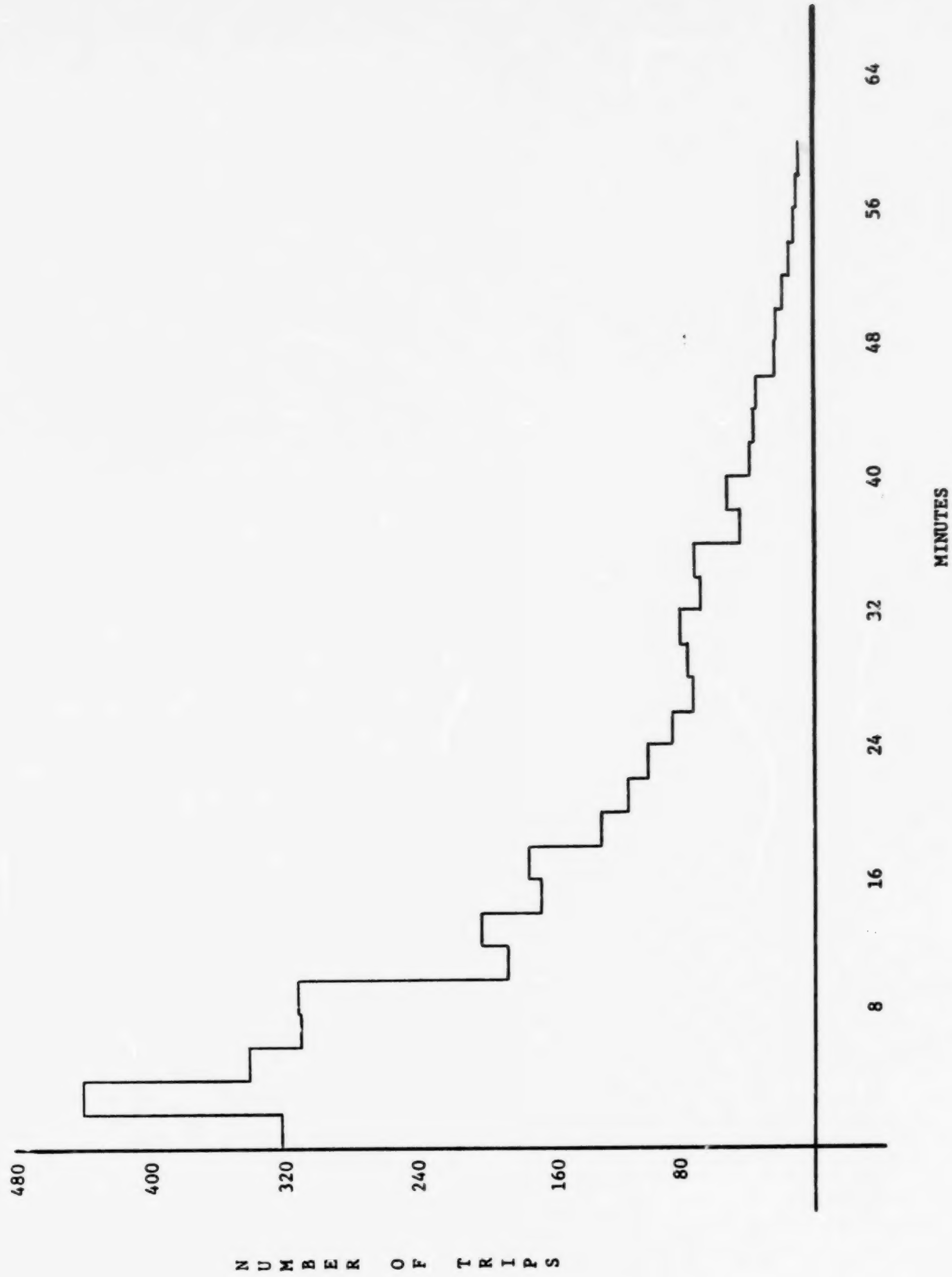

FIGURE 1-20

DISTRIBUTION OF TRIP TIME, WEEKDAY TRIPS

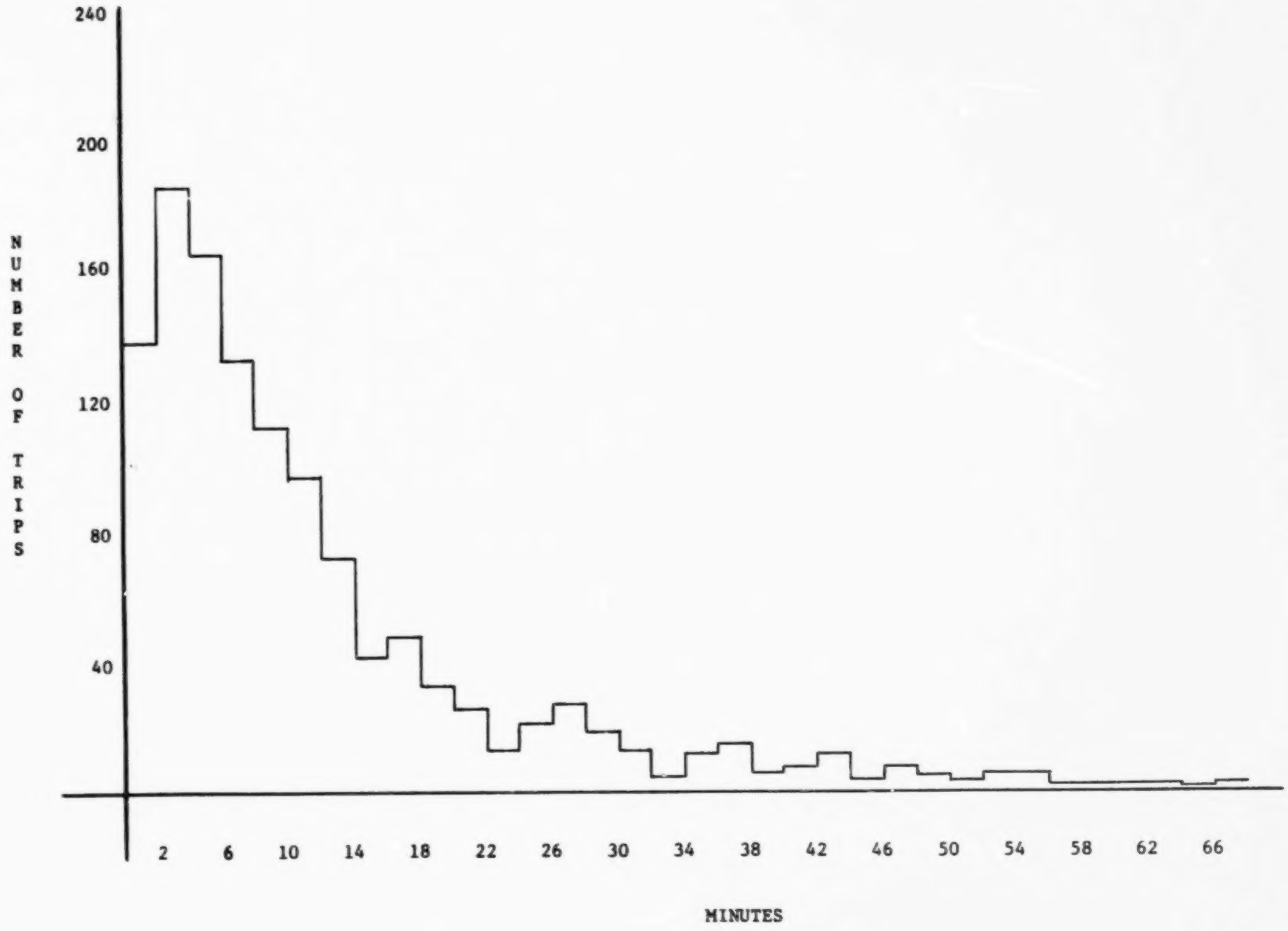

FIGURE 1-21

DISTRIBUTION OF TRIP TIME, WEEKEND TRIPS

TABLE 1-21

DISTRIBUTION OF WEEKDAY TRIPS BY TRIP SEGMENT STRING SHOWING TRIP ELAPSED TIME IN MINUTES PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
N: NUMBER OF CASES ELAPSED TIME (MIN)	37 11.1	373 14.1	164 8.4	322 7.8	311 9.6	611 11.8	484 7.9	180 10.1	2482 10.2
NFN: NUMBER OF CASES ELAPSED TIME	25 29.3	336 29.5	83 24.8	75 23.3	121 29.1	267 32.1	89 23.9	47 27.1	1043 28.7
NFNFN: NUMBER OF CASES ELAPSED TIME	2 75.0	29 45.3	4 26.0	3 52.3	8 48.2	22 39.7	4 23.5	1 71.0	73 43.2
OTHER: NUMBER OF CASES ELAPSED TIME	2 12.0	12 23.5	3 29.7	1 45.0	5 12.6	10 26.6	6 16.0	2 10.0	41 21.6
TOTAL: NUMBER OF CASES ELAPSED TIME	66 20.0	750 22.3	254 14.3	401 11.2	445 15.6	910 18.6	583 10.5	230 13.8	3639 16.3

TABLE 1-22

DISTRIBUTION OF WEEKEND TRIPS BY TRIP SEGMENT STRING SHOWING TRIP ELAPSED TIME IN MINUTES PER TRIP FOR EACH CASE

TRIP SEGMENT STRING	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
N: NUMBER OF CASES ELAPSED TIME (MIN)	55 12.6	152 7.2	201 8.2	375 9.3	178 7.9	56 10.0	1017 8.7
NFN: NUMBER OF CASES ELAPSED TIME	32 24.9	19 35.1	28 29.6	62 30.8	37 27.7	27 34.6	205 30.1
NFNFN: NUMBER OF CASES ELAPSED TIME	1 89.0	3 35.7	3 50.3	5 70.2	1 53.0	1 27.0	14 55.6
OTHER: NUMBER OF CASES ELAPSED TIME	0 0	1 7.0	2 55.0	3 13.0	0 0	0 0	6 26.0
TOTAL: NUMBER OF CASES ELAPSED TIME	88 17.9	175 10.7	234 11.7	445 13.1	216 11.5	84 18.1	1242 12.9

TABLE 1-23

AVERAGE ELAPSED TIME IN MINUTES FOR SEGMENTS OF WEEKDAY FREEWAY TRIPS BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT 0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2050	2100-2359	TOTAL
NONFREEWAY[1]									
NUMBER OF CASES	54	763	189	166	246	630	226	107	2381
ELAPSED TIME	8.8	8.4	11.5	9.6	7.0	8.6	6.6	11.0	8.6
FREEWAY									
NUMBER OF CASES	36	407	97	81	128	338	115	61	1255
ELAPSED TIME	12.4	12.2	13.3	9.1	12.2	14.6	13.1	12.7	12.9
TOTAL									
NUMBER OF CASES	90	1170	286	247	374	968	341	168	3636
ELAPSED TIME	10.2	9.7	12.1	9.5	8.8	10.7	8.8	11.6	10.1

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS (I.E., TRIPS WITH N-TRIP SEGMENT SEQUENCE)

Trip and Segment Idling

Although our survey results provide quantitative estimates of idling time, for reasons discussed in Part III of this report, we attach more significance to our counts of momentary stops as an accurate indicator of the degree of idling in a trip. The mean number of such stops per trip by time slot and trip segment string are shown in Tables 1-24 and 1-25 for weekday and weekend trips respectively. Table 1-26 shows the mean number of such stops for trip segments in weekday trips utilizing freeways. One notes that during rush hours, there is an increase in the mean number of stops on freeway segments, somewhat more pronounced during the evening rush hour.

Elapsed Time Between Trips

Figures 1-22 and 1-23 show the distribution of elapsed time between trips for weekday and weekend. The time scale on each figure is broken in five places: at one hour, to enable a more precise breakdown of shorter inter-trip times; and at one, two, three, and four days to enable the agglomeration of larger inter-trip times. Tables 1-27 and 1-28 show the breakdown of elapsed time from last trip by time slot and purpose of trip for weekday and weekend trips. Since this quantity is not associated with the trip segment structure but is quite clearly associated with trip purpose, we believe this breakdown is more reasonable than that based upon the time slot trip segment string criterion used previously.

In addition to this quantity, the survey results also contain data on the incidence of engine-off stops of less than five minutes. This quantity does not show up as an elapsed time between trips since if such a stop occurred, the computer program merged the two trips into a single record. The incidence of such stops was very meager. Table 1-29 shows the results for weekdays and weekend trips. Four engine-off stops was the maximum case on any trip.

TABLE 1-24

DISTRIBUTION OF WEEKDAY TRIPS BY TRIP SEGMENT STRING
SHOWING NUMBER OF TRIP STOPS WITH ENGINE ON PER TRIP FOR EACH CASE

TRIP SEGMENT STRING		TIME SLOT								TOTAL
		0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2350	
N:	NUMBER OF CASES	37	373	164	322	311	612	484	181	2484
	NUMBER OF STOPS (ENGINE ON)	6.4	10.6	5.9	6.1	7.1	11.6	5.3	5.9	8.1
NFN:	NUMBER OF CASES	26	337	83	75	121	268	89	48	1047
	NUMBER OF STOPS	9.8	10.4	7.2	8.8	11.7	13.8	6.6	12.1	10.8
NFNFN:	NUMBER OF CASES	2	30	4	3	8	23	5	1	76
	NUMBER OF STOPS	18.5	11.5	9.8	8.7	16.6	14.2	15.0	48.0	13.6
OTHER:	NUMBER OF CASES	2	12	3	1	6	10	6	2	42
	NUMBER OF STOPS	3.5	10.9	3.7	35.0	12.5	14.2	10.0	12.5	11.6
TOTAL:	NUMBER OF CASES	67	752	254	401	446	913	584	232	3649
	NUMBER OF STOPS	8.1	10.5	6.4	6.7	8.6	12.4	5.6	6.7	9.0

TABLE 1-25

DISTRIBUTION OF WEEKEND TRIPS BY TRIP SEGMENT STRING
SHOWING NUMBER OF TRIP STOPS WITH ENGINE ON PER TRIP FOR EACH CASE

TRIP SEGMENT STRING		TIME SLOT						TOTAL
		0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
N:	NUMBER OF CASES	55	152	201	375	178	56	1017
	NUMBER OF STOPS (ENGINE ON)	8.4	5.0	6.1	6.3	4.9	5.5	5.9
NFN:	NUMBER OF CASES	33	19	29	64	39	27	211
	NUMBER OF STOPS	7.4	7.1	7.8	10.3	7.8	8.5	8.5
NFNFN:	NUMBER OF CASES	1	3	3	6	1	1	15
	NUMBER OF STOPS	14.0	9.0	17.0	16.0	17.0	7.0	14.1
OTHER:	NUMBER OF CASES	0	1	3	4	1	0	9
	NUMBER OF STOPS	0	2.0	14.3	6.5	6.1	0	14.7
TOTAL:	NUMBER OF CASES	89	175	236	449	219	84	1252
	NUMBER OF STOPS	8.1	5.2	6.5	7.0	5.8	6.5	6.5

TABLE 1-26

AVERAGE NUMBER OF ENGINE-ON STOPS FOR SEGMENTS OF WEEKDAY FREEWAY TRIPS BY TIME SLOT AND ROUTE TYPE

ROUTE TYPE	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
NONFREEWAY[1]									
NUMBER OF CASES	54	763	189	166	246	629	227	106	2380
NUMBER OF STOPS	4.7	4.3	3.0	4.0	5.2	3.8	3.3	4.5	4.1
FREEWAY									
NUMBER OF CASES	36	407	97	81	128	338	115	61	1255
NUMBER OF STOPS	0.1	1.5	0.4	0.1	0.5	2.2	0.4	0.2	1.2
TOTAL									
NUMBER OF CASES	90	1170	286	247	374	967	342	167	3635
NUMBER OF STOPS	2.9	3.3	2.1	2.7	3.6	3.2	2.3	2.9	3.1

[1] EXCLUDES NONFREEWAY SEGMENTS IN NONFREEWAY TRIPS (I.E., TRIPS WITH "N" TRIP SEGMENT SEQUENCE)

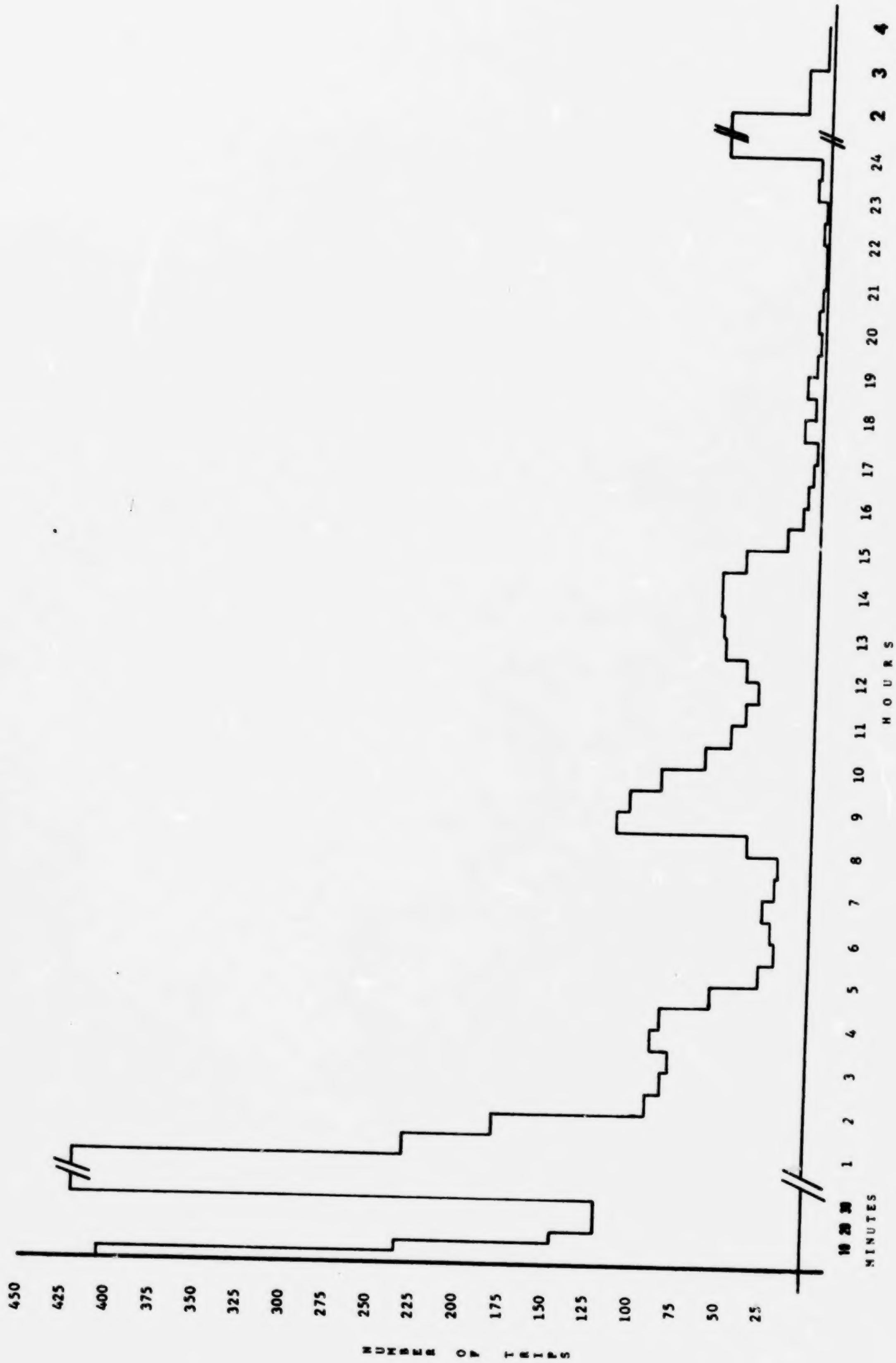

FIGURE 1-22

DISTRIBUTION OF ELAPSED TIME BETWEEN TRIPS, WEEKDAY

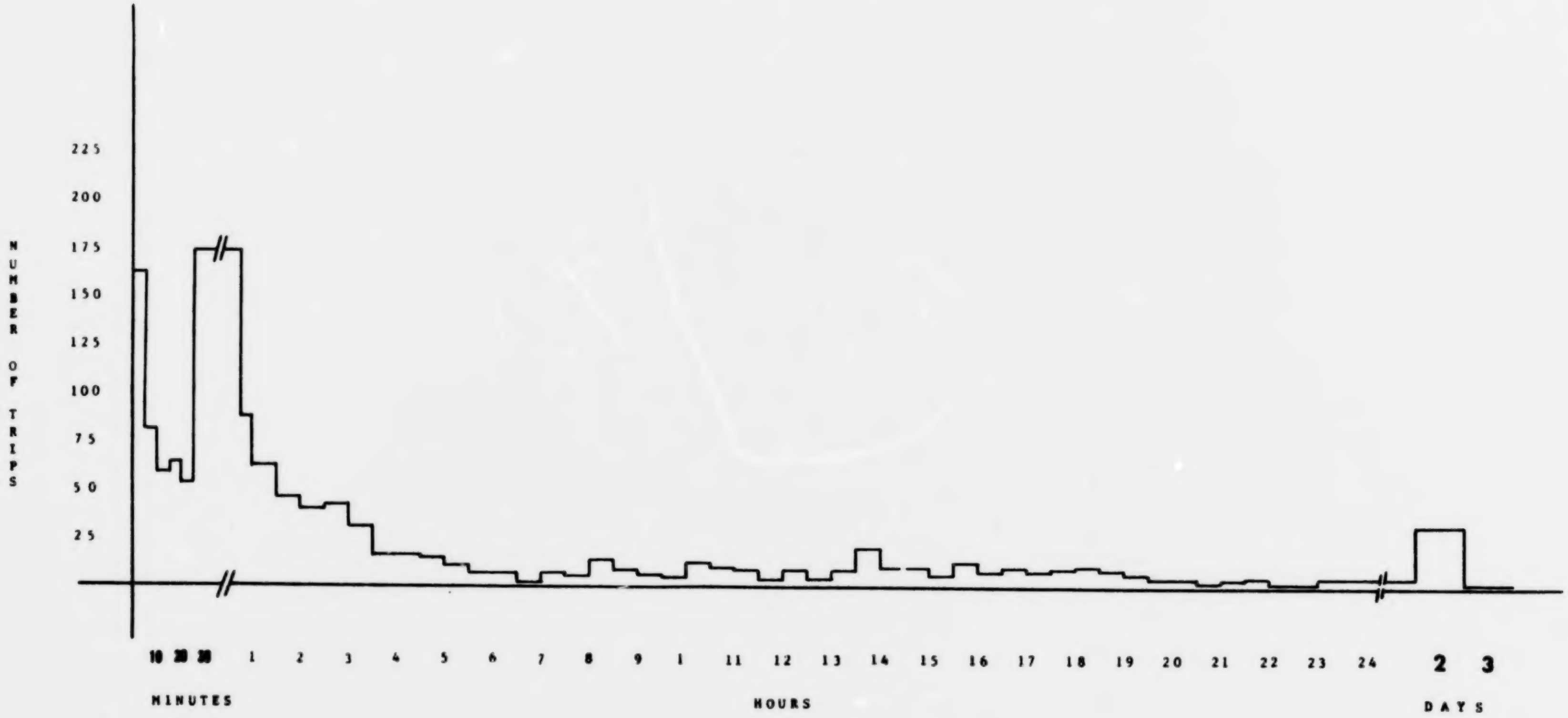

FIGURE 1-23

DISTRIBUTION OF ELAPSED TIME BETWEEN TRIPS, WEEKEND

TABLE 1-27

ELAPSED TIME BETWEEN WEEKDAY TRIPS BY TIME SLOT AND TRIP PURPOSE

PURPOSE OF TRIP	TIME SLOT								TOTAL
	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	
GO HOME	33 4:41	20 8:41	20 2:36	46 1:41	103 4:26	451 4:43	222 1:36	140 2:24	1035 3:37
GO TO WORK	7 14:43	602 13:12	53 4:49	115 0:51	69 2:19	26 4:05	11 1:46	1 3:45	884 9:50
BUSINESS	3 4:42	46 7:56	116 1:29	93 1:44	110 1:28	27 4:22	16 1:52	9 1:43	420 2:28
SHOPPING	7 3:45	50 13:52	36 7:32	114 3:42	94 5:42	212 4:08	176 1:49	26 2:02	715 4:28
CHURCH, SCHOOL, ETC.	0 0	3 14:15	4 10:08	0 0	1 22:15	11 5:36	13 2:54	0 0	32 6:24
RECREATION	16 2:16	27 13:18	15 7:17	20 2:52	31 2:26	99 3:18	142 2:40	53 1:59	403 3:24
TOTAL	66 5:04	748 12:48	244 3:42	388 2:06	408 3:27	826 4:23	580 1:58	229 2:15	3489 5:15

TABLE 1-28

ELAPSED TIME BETWEEN WEEKEND TRIPS BY TIME SLOT AND TRIP PURPOSE

PURPOSE OF TRIP	TIME SLOT						TOTAL
	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	
GO HOME	36 4:43	36 1:57	80 1:38	144 2:36	84 2:02	49 3:22	429 2:31
GO TO WORK	12 12:40	12 9:26	4 8:14	7 8:25	3 2:06	0 0	38 9:34
BUSINESS	3 9:55	1 10:45	6 3:20	6 3:47	4 4:00	0 0	20 4:58
SHOPPING	15 8:01	79 9:55	90 7:05	163 4:25	52 3:57	9 5:47	408 6:10
CHURCH, SCHOOL, ETC.	3 14:05	9 12:56	1 11:45	3 7:02	0 0	0 0	16 11:58
RECREATION	19 3:48	38 8:43	55 4:47	26 5:52	76 2:48	26 2:50	340 4:45
TOTAL	88 6:40	175 8:09	236 4:39	449 4:18	219 2:48	84 3:27	1251 4:42

TABLE 1-29

NUMBER OF CASES OF ENGINE-OFF STOPS FOR WEEKDAY AND WEEKEND TRIPS

NUMBER OF STOPS	NUMBER OF TRIPS	
	WEEKDAY	WEEKEND
0	3399 (93%)	1155 (92%)
1	229 (6%)	85 (7%)
2	17 (1%)	9 (1%)
3	2	0
4	2	1

Parking

The results obtained on parking habits during the survey indicate a high likelihood that most residents of the Los Angeles area leave their cars outdoors both at night and between trips. Table 1-30 shows the results for weekdays and weekends. Survey participants were told that only closed garages constituted indoor parking.

TABLE 1-30

INDOOR AND OUTDOOR PARKING OVERNIGHT AND BETWEEN TRIPS FOR WEEKDAYS AND WEEKEND DAYS

	INDOOR	OUTDOOR
WEEKDAYS:		
BETWEEN TRIPS	349 (9.6%)	3295 (90.4%)
OVERNIGHT	202 (25.4%)	590 (74.6%)
WEEKEND DAYS:		
BETWEEN TRIPS	107 (8.6%)	1145 (91.4%)
OVERNIGHT	58 (23.2%)	192 (76.8%)

Overnight Fuel Tank Readings

Table 1-31 shows the percentage of fuel tank readings at the empty, one-quarter, one-half, three-quarter, and full levels for weekdays and weekend days. Survey participants were asked to note the reading at the start of the day's travel.

TABLE 1-31

OVERNIGHT FUEL TANK READINGS FOR WEEKDAYS AND WEEKEND DAYS
(EXPRESSED AS A PERCENTAGE OF CAR-DAYS FOR THE TWO CATEGORIES)

READING	PERCENTAGE OF CAR-DAYS	
	WEEKDAY	WEEKEND
EMPTY	8.3%	9.5%
1/4	22.9%	23.1%
1/2	25.5%	33.0%
3/4	20.4%	21.3%
FULL	22.9%	13.1%

Use of Freeways Versus Surface Streets

Approximately 70% of all weekday trips and 80% of all weekend trips were made entirely on surface streets. The previous tables showing the breakdown of trip descriptor variables by trip segment string indicate that the freeway trip is both longer and carried out at a greater average speed than the nonfreeway trip. It is not clear, however, whether it is the distance that the driver must cover between his origin and destination or the speed advantage he may obtain that attracts the driver to the freeway. In order to examine this question more closely, Figures 1-24 through 1-31 were prepared showing the distribution of nonfreeway trips and trips with at least one freeway segment by three mile distance increments within the eight time slots. These figures clearly indicate to the authors that the choice of whether or not to use a freeway is dependent upon the distance the driver must cover. In fact, although the overall distribution curves are exponential in character, it is seen that the distribution of freeway trips is approximately bell-shaped with respect to distance as the independent variable. It is the overwhelming number of short trips which usually do not involve freeways and are exponentially distributed with respect to distance that creates the overall exponential appearance to the distribution curve. Therefore, the tendency on the part of residents in Los Angeles to use their automobiles for very short trips, many of which undoubtedly cannot utilize freeways conveniently anyway, contributes to the seemingly imbalance in the choice between freeway or surface street. During the survey period however, of the approximately 26,000 miles driven by participants on weekdays, about 17,600 miles (68%) were driven on trips which utilized freeways and about 11,301 of these were actual freeway miles.

In subsequent cities to be studied in this project, the division between freeway and surface street utilization will be examined both in terms of the average trip distance (propensity of drivers to use their cars when walking might be more convenient) and the adequacy of the freeway grid structure (can short trips be made by freeway because of convenient on and off ramps).

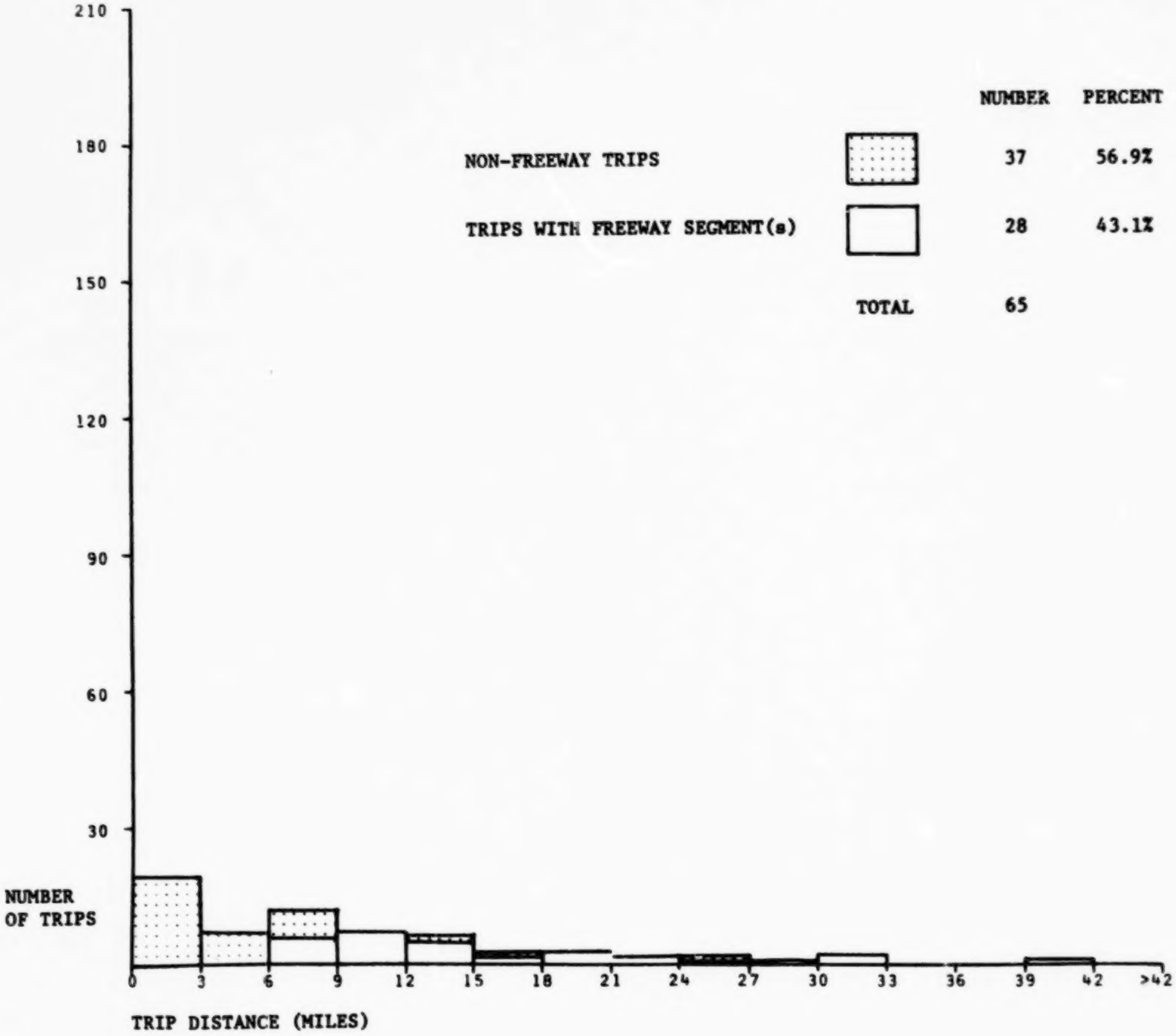

FIGURE 1-24

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT ONE (0000 - 0559)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

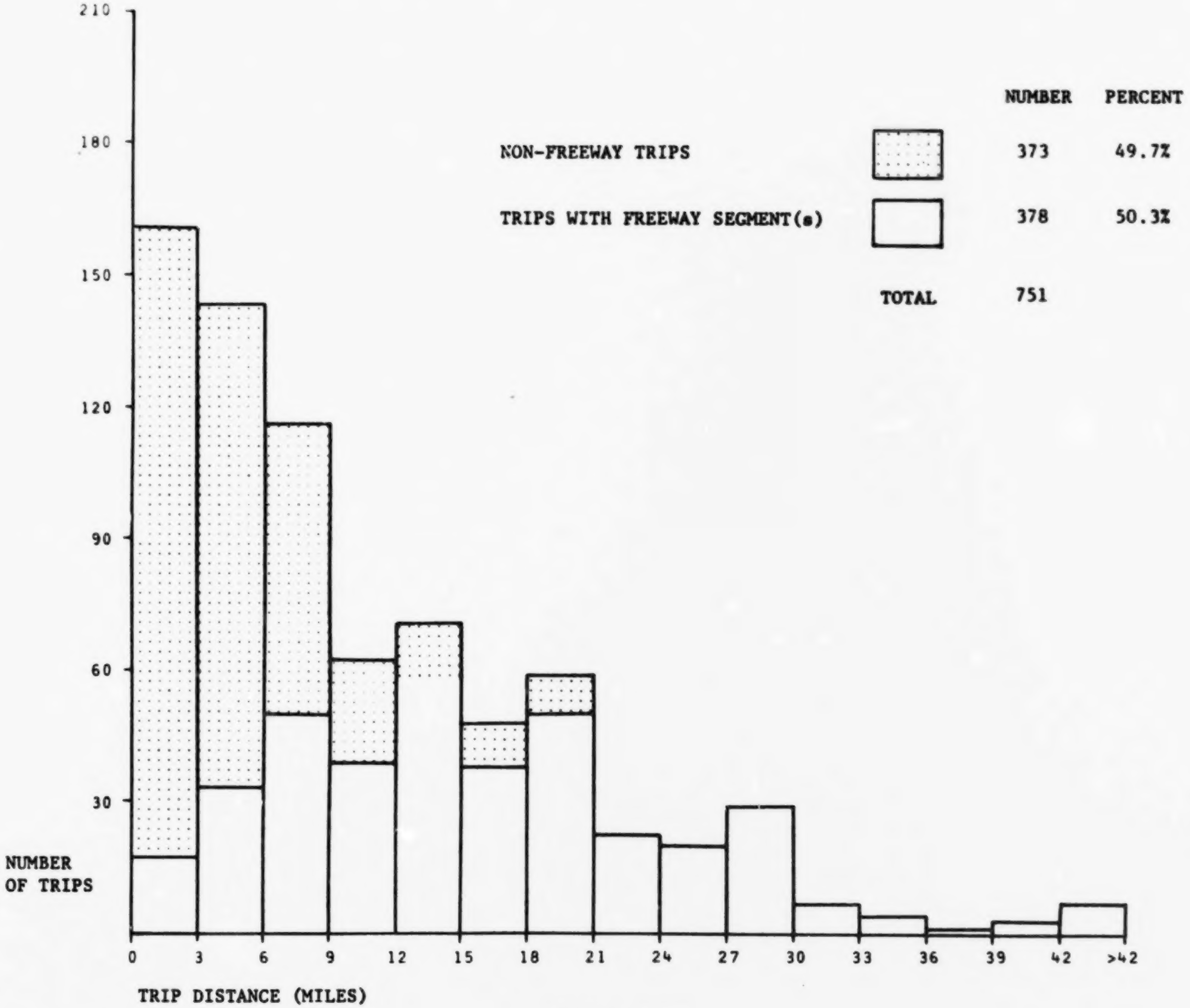

FIGURE 1-25

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT TWO (0600 - 0859)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

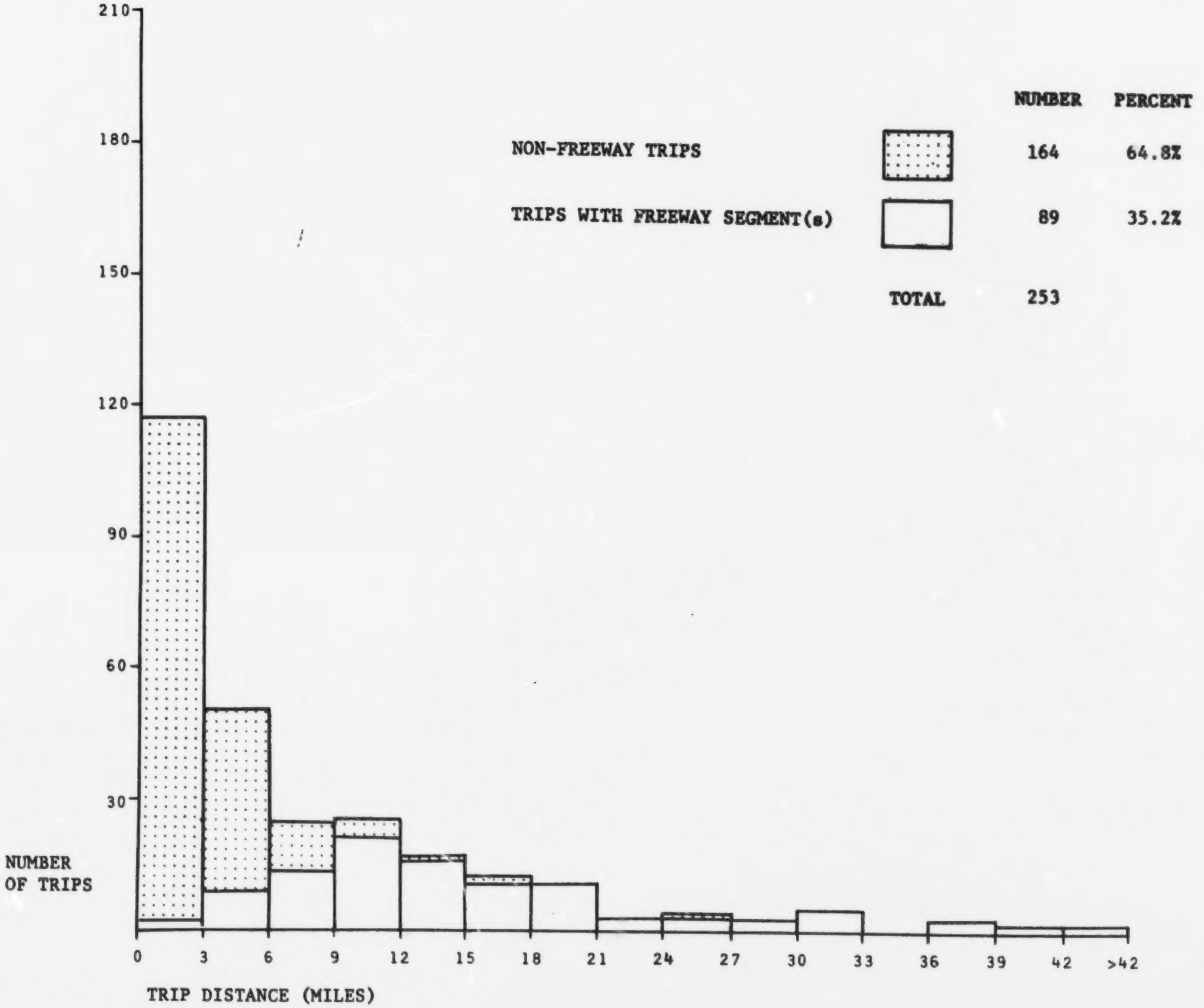

FIGURE 1-26

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT THREE (0900 - 1129)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

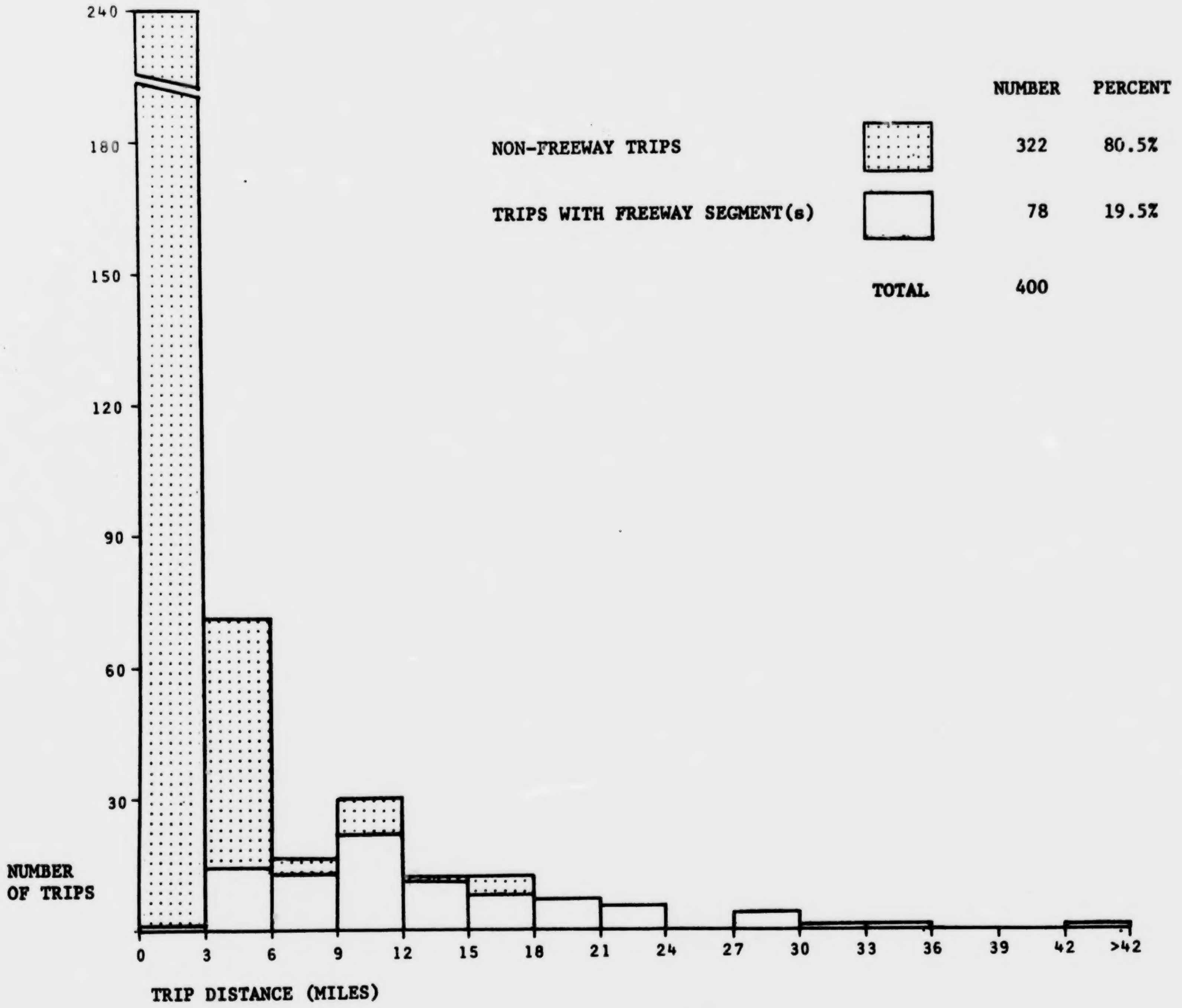

FIGURE 1-27

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT FOUR (1130 - 1329)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

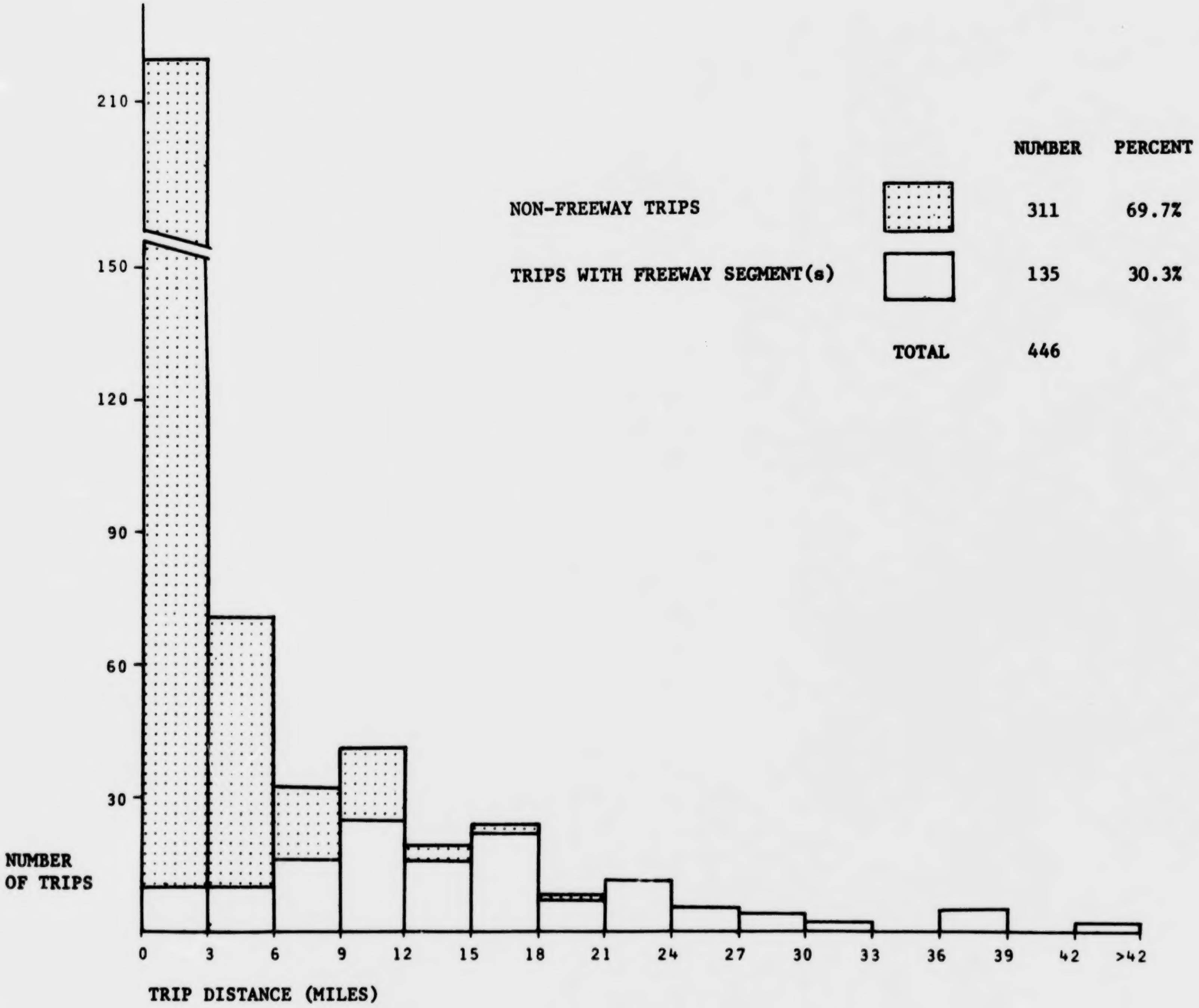

FIGURE 1-28

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT FIVE (1330 - 1629)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

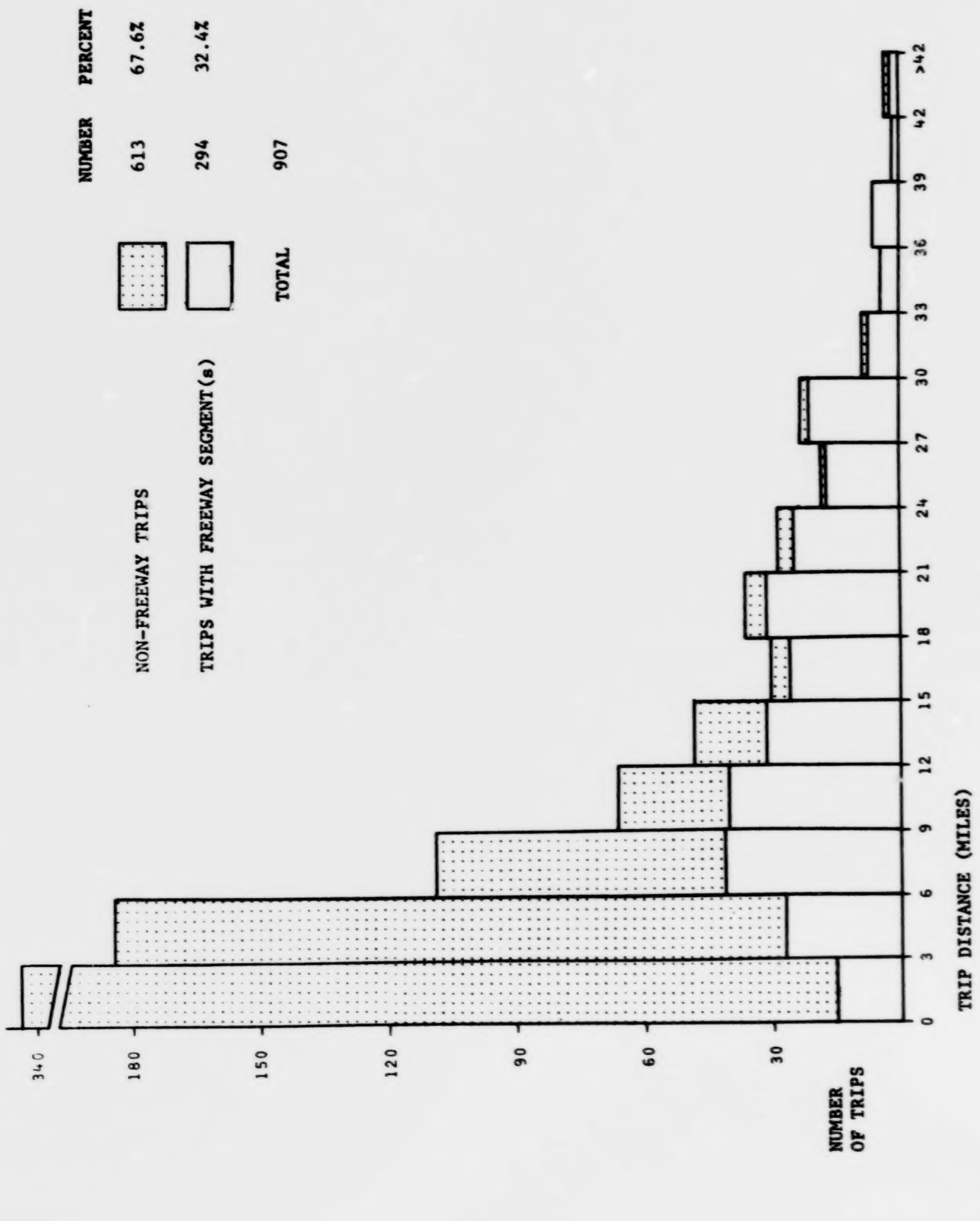

FIGURE 1-29

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT SIX (1630 - 1829)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

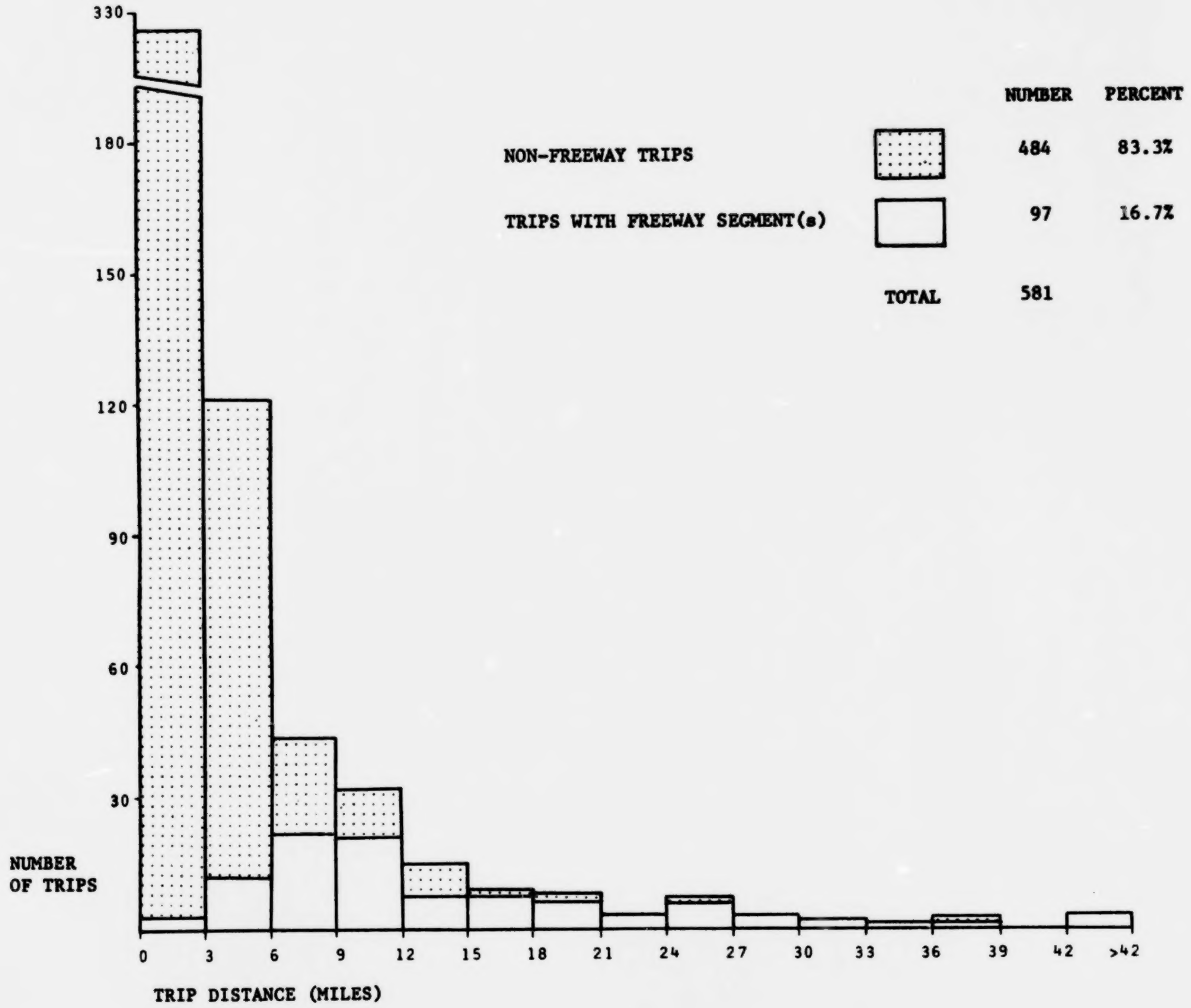

FIGURE 1-30

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT SEVEN (1830 - 2059)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

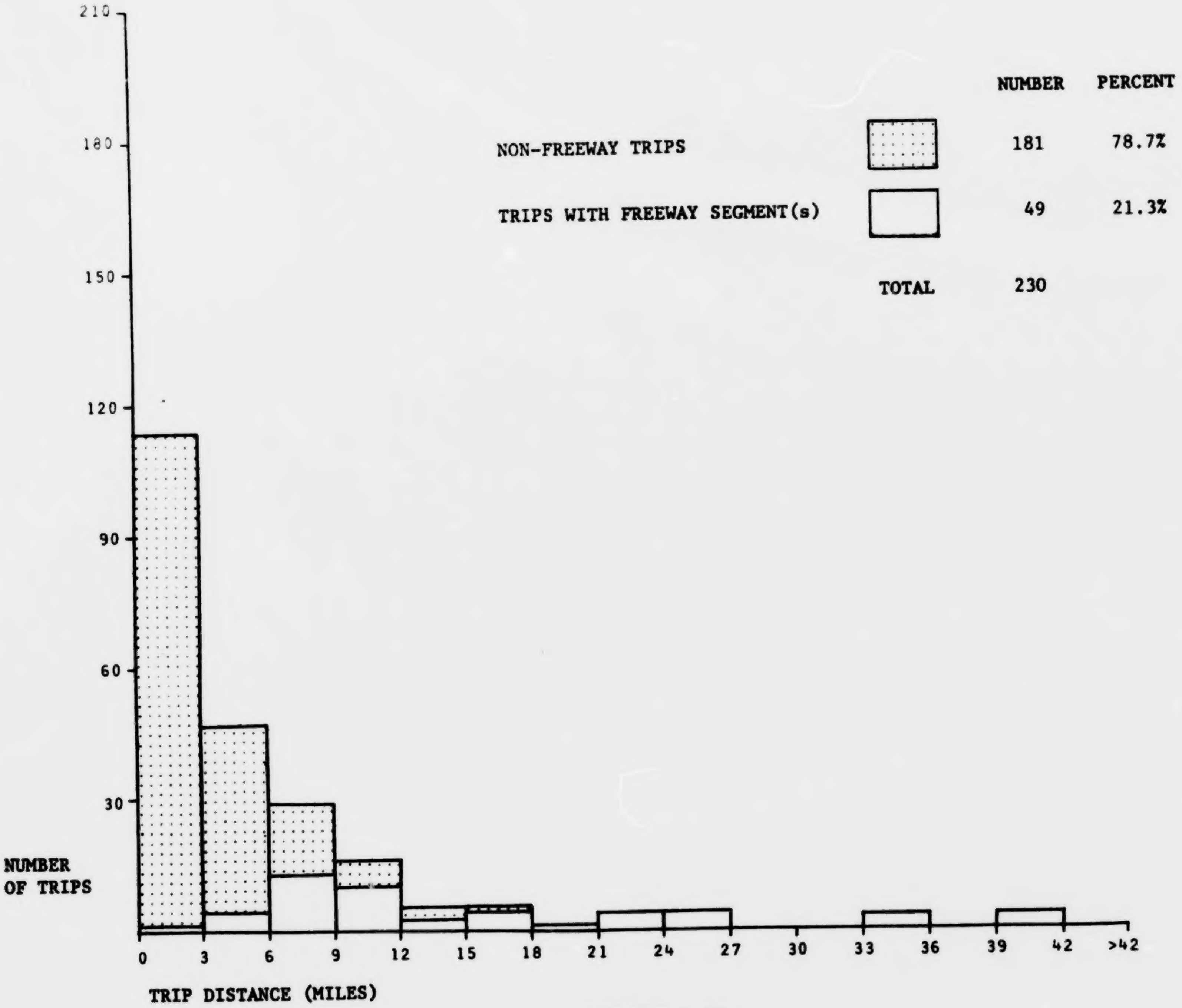

FIGURE 1-31

DISTRIBUTION OF TRIP DISTANCE IN TIME SLOT EIGHT (2100 - 2359)
SHOWING DIVISION BETWEEN FREEWAY AND NON-FREEWAY TRIPS

FROM TIME SLOT / TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
PREVIOUS DAY	7	126 H-W	6	2	3	2	1	0
0000-0559	10	6	1	0	0	0	0	0
0600-0859		19	14	18	14	49 W-H W-S	3	0
0900-1129			19	13	4	5	0	1
1130-1329				29	17	17	1	0
1330-1629					34	54 W-H	4	1
1630-1829						66 S-H H-S	60 H-S S-H	7
1830-2059							64 S-H S-S	15
2100-2359								5

MONDAY

TOTAL TRIPS: 697

LEGEND

H - Home	S - Shopping
W - Work	C - Church, School, etc.
B - Business	R - Recreation

FIGURE 1-32

TWO-STEP TRIP-TO-TRIP

TRANSITION MATRIX, MONDAY

TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
FROM TIME SLOT PREVIOUS DAY	5	131 H-W	3	1	1	4	2	0
0000-0559	3	4	2	0	0	0	0	0
0600-0859		26	24	14	18	47 W-H W-S	5	0
0900-1129			33 B-B	20	6	6	1	0
1130-1329				31	20	14	4	0
1330-1629					37	50 W-H	6	1
1630-1829						60 S-H	58 H-S H-R	6
1830-2059							50 S-H	23
2100-2359								16

TUESDAY

TOTAL TRIPS: 732

LEGEND

H - Home
W - Work
B - Business
S - Shopping
C - Church, School, etc.
R - Recreation

FIGURE 1-33

TWO-STEP TRIP-TO-TRIP TRANSITION MATRIX, TUESDAY

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
PREVIOUS DAY	10	122 H-W	6	1	5	3	2	0
0000-0559	3	5	2	1	0	0	1	0
0600-0859		21	18	21	13	43 W-H	2	1
0900-1129			24	16	4	3	1	1
1130-1329				40	18	19	0	0
1330-1629					46 B-B	55 W-H	6	1
1630-1829						56 S-H	53 H-S	5
1830-2059							43 S-H	25
2100-2359								16

WEDNESDAY

TOTAL TRIPS: 712

LEGEND

H - Home
W - Work
B - Business
S - Shopping
C - Church, School, etc.
R - Recreation

FIGURE 1-34

TWO-STEP TRIP-TO-TRIP
TRANSITION MATRIX, WEDNESDAY

TO TIME SLOT FROM TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
PREVIOUS DAY	9	112 H-W	13	3	4	6	3	0
0000-0559	6	4	2	0	0	2	0	0
0600-0859		5	11	23	10	40 W-H	3	1
0900-1129			24	24	3	4	1	1
1130-1329				36	22	21	4	0
1330-1629					53 B-B	39 W-H	6	1
1630-1829						53 Random	54 Random	8
1830-2059							38 S-S	33 R-H
2100-2359								10

THURSDAY

TOTAL TRIPS: 692

LEGEND

H - Home	S - Shopping
W - Work	C - Church, School, etc.
B - Business	R - Recreation

FIGURE 1-35

TWO-STEP TRIP-TO-TRIP
TRANSITION MATRIX, THURSDAY

FROM TIME SLOT \ TO TIME SLOT	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359
PREVIOUS DAY	6	130 H-W	7	4	2	2	0	1
0000-0559	1	5	0	2	0	0	0	0
0600-0859		21	20	27	19	56 W-H W-S	2	0
0900-1129			24	17	1	8	1	0
1130-1329				47 S-W	29	18	1	1
1330-1629					44 Random	41	7	1
1630-1829						82 S-H S-S H-R	52 R-H S-H	9
1830-2059							53 S-H	24
2100-2359								21

FRIDAY

TOTAL TRIPS: 786

LEGEND

H - Home	S - Shopping
W - Work	C - Church, School, etc.
B - Business	R - Recreation

FIGURE 1-36

TWO-STEP TRIP-TO-TRIP
TRANSITION MATRIX, FRIDAY

FROM TIME SLOT / TO TIME SLOT	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359
PREVIOUS DAY	28	51 H-S	20	26	4	2
0000-0829	11	10	5	14	0	0
0830-1059		55 S-S S-H	34	14	3	1
1100-1259			68 S-H S-S	47 H-S	3	1
1300-1759				151 S-S S-H	59 H-R R-H H-S	5
1800-2059					51 S-H H-R R-R R-H	26
2100-2359						7

SATURDAY

TOTAL TRIPS: 696

LEGEND

H - Home
W - Work
B - Business
S - Shopping
C - Church, School, etc.
R - Recreation

FIGURE 1-37

TWO-STEP TRIP-TO-TRIP
TRANSITION MATRIX, SATURDAY

FROM TIME SLOT \ TO TIME SLOT	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359
PREVIOUS DAY	37	26	26	28	1	0
0000-0829	9	15	8	6	4	1
0830-1059		19	26	10	1	0
1100-1259			46	47	3	0
1300-1759				102 S-H R-R	49	7
1800-2059					45	22
2100-2359						14

SUNDAY

TOTAL TRIPS: 552

LEGEND

H - Home	S - Shopping
W - Work	C - Church, School, etc.
B - Business	R - Recreation

FIGURE 1-38

TWO-STEP TRIP-TO-TRIP

TRANSITION MATRIX, SUNDAY

TABLE 1-32

FREQUENCY OF TRIP PURPOSE AND TRIP SEGMENT STRING BY TIME SLOT FOR ALL MONDAY TRIPS

TIME SLOT PURPOSE	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	TOTALS
GO HOME	6	2	0	5	21	106	59	23	222
GO TO WORK	1	123	8	18	11	4	2	0	167
BUSINESS	0	8	23	25	24	5	4	0	89
SHOPPING	2	11	5	17	13	53	43	4	148
SCHOOL	0	0	1	0	0	3	5	0	9
RECREATION	9	6	3	4	3	19	20	1	65
TOTALS	18	150	40	69	72	190	133	28	700

TIME SLOT TRIP SEGMENT STRING	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	TOTALS
N	10	75	26	52	50	130	113	19	475
NFN	6	69	13	17	19	55	19	9	207
NFNFN	1	5	1	0	2	4	0	0	13
OTHER	1	1	0	0	1	1	1	0	5
TOTALS	18	150	40	69	72	190	133	28	700

TABLE 1-33

FREQUENCY OF TRIP PURPOSE AND TRIP SEGMENT STRING BY TIME SLOT FOR ALL TUESDAY TRIPS

TIME SLOT / PURPOSE	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	TOTALS
GO HOME	6	5	7	7	26	103	50	24	228
GO TO WORK	2	122	10	21	18	6	0	0	179
BUSINESS	1	9	27	20	20	3	5	7	92
SHOPPING	1	15	13	16	15	53	37	2	152
SCHOOL	0	1	1	0	0	1	5	0	8
RECREATION	1	11	4	4	5	16	26	12	79
TOTALS	11	163	62	68	84	182	123	45	738

TIME SLOT / TRIP SEGMENT STRING	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	TOTALS
N	5	84	49	57	57	123	100	38	513
NFN	6	71	12	10	25	51	20	6	201
NFNFN	0	6	0	0	1	5	1	0	13
OTHER	0	2	1	1	1	3	2	1	11
TOTALS	11	163	62	68	84	182	123	45	738

TABLE 1-34

FREQUENCY OF TRIP PURPOSE AND TRIP SEGMENT STRING BY TIME SLOT FOR ALL WEDNESDAY TRIPS

TIME SLOT / PURPOSE	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	TOTALS
GO HOME	8	2	6	9	23	100	43	29	220
GO TO WORK	2	121	16	24	19	7	3	0	192
BUSINESS	2	11	20	19	22	6	1	2	83
SHOPPING	0	10	8	21	21	39	29	9	137
SCHOOL	0	0	1	0	1	4	2	0	8
RECREATION	2	5	1	4	4	22	28	10	76
TOTALS	14	149	52	77	90	178	106	50	716

TIME SLOT / TRIP SEGMENT STRING	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	TOTALS
N	9	78	30	62	59	115	87	43	483
NFN	4	63	21	15	28	58	17	7	213
NFNFN	0	6	1	0	2	4	1	0	14
OTHER	1	2	0	0	1	1	1	0	6
TOTALS	14	149	52	77	90	178	106	50	716

TABLE 1-35

FREQUENCY OF TRIP PURPOSE AND TRIP SEGMENT STRING BY TIME SLOT FOR ALL THURSDAY TRIPS

TIME SLOT PURPOSE	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	TOTALS
GO HOME	9	8	7	15	29	89	34	38	229
GO TO WORK	2	108	10	26	12	7	2	0	167
BUSINESS	0	4	18	9	29	10	5	0	75
SHOPPING	2	6	9	32	22	28	32	5	136
SCHOOL	0	1	1	0	0	2	1	0	5
RECREATION	3	4	5	6	11	22	33	9	93
TOTALS	16	131	50	88	103	158	107	52	705

TIME SLOT TRIP SEGMENT STRING	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	TOTALS
N	8	63	35	74	73	109	89	33	484
NFN	7	58	14	13	27	43	15	18	195
NFNFN	1	6	1	1	2	5	2	1	19
OTHER	0	4	0	0	1	1	1	0	8
TOTALS	16	131	50	88	103	158	107	52	705

TABLE 1-36

FREQUENCY OF TRIP PURPOSE AND TRIP SEGMENT STRING BY TIME SLOT FOR ALL FRIDAY TRIPS

TIME SLOT PURPOSE	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	TOTALS
GO HOME	5	3	1	12	27	110	40	29	227
GO TO WORK	0	131	10	28	14	7	4	1	195
BUSINESS	0	14	33	24	20	7	1	0	99
SHOPPING	2	8	4	31	28	55	35	6	169
SCHOOL	0	1	0	0	0	1	0	0	2
RECREATION	1	2	2	4	8	25	35	21	98
TOTALS	8	159	50	99	97	205	115	57	790

TIME SLOT TRIP SEGMENT STRING	0000-0559	0600-0859	0900-1129	1130-1329	1330-1629	1630-1829	1830-2059	2100-2359	TOTALS
N	5	73	24	77	72	135	95	48	529
NFN	3	76	23	20	22	61	18	8	231
NFNFN	0	7	1	2	1	5	1	0	17
OTHER	0	3	2	0	2	4	1	1	13
TOTALS	8	159	50	99	97	205	115	57	790

TABLE 1-37

FREQUENCY OF TRIP PURPOSE AND TRIP SEGMENT STRING BY TIME SLOT FOR ALL SATURDAY TRIPS

TIME SLOT PURPOSE	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	TOTALS
GO HOME	15	22	41	81	45	24	288
GO TO WORK	9	9	2	4	1	0	25
BUSINESS	1	0	4	2	2	0	9
SHOPPING	10	65	53	114	25	4	271
SCHOOL	0	1	0	1	0	0	2
RECREATION	8	18	27	53	46	12	164
TOTALS	43	115	127	255	119	40	699

TIME SLOT TRIP SEGMENT STRING	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	TOTALS
N	26	98	112	215	92	24	567
NFN	16	14	12	37	25	15	119
NFNFN	1	3	1	2	1	1	9
OTHER	0	0	2	1	1	0	4
TOTALS	43	115	127	255	119	40	699

TABLE 1-38

FREQUENCY OF TRIP PURPOSE AND TRIP SEGMENT STRING BY TIME SLOT FOR ALL SUNDAY TRIPS

PURPOSE \ TIME SLOT	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	TOTALS
GO HOME	21	14	33	63	39	25	195
GO TO WORK	3	3	8	3	2	0	19
BUSINESS	2	1	2	4	2	0	11
SHOPPING	6	14	37	49	27	5	138
SCHOOL	3	8	1	2	0	0	14
RECREATION	11	20	28	73	30	14	176
TOTALS	46	60	109	194	100	44	553

TRIP SEGMENT STRING \ TIME SLOT	0000-0829	0830-1059	1100-1259	1300-1759	1800-2059	2100-2359	TOTALS
N	29	54	89	160	86	32	450
NFN	17	5	17	27	14	12	92
NFNFN	0	0	2	4	0	0	6
OTHER	0	1	1	3	0	0	5
TOTALS	46	60	109	194	100	44	553

PART II

SURVEY TECHNIQUE

DESCRIPTION OF SURVEY PROCEDURE

The survey procedure was designed to obtain data from which typical driving patterns could be derived. Three basic steps were taken in the data gathering phase of the survey: design of the survey sample; selection of the survey participants; and collection of data. Subsequent sections of this part of the report cover each of these steps in detail.

The sample for the Los Angeles Driving Patterns Survey was designed to obtain data on an adequate number of trips to ensure that description of trip variables would be statistically accurate. Fifty Tachograph recording devices were purchased and data were collected from each participating automobile for one week. The original proposal specified a two-week sampling period in Los Angeles to obtain data on 100 cars. However, at an early meeting with the CRC Air Pollution Research Advisory Committee (APRAC)[1], it was decided to increase sample size and sampling period to 200 cars and four weeks, respectively.

The sample was stratified four ways in terms of residence type (single family and multiple family dwelling) and car ownership (single car and multiple car). These stratification criteria were based on data from the continuing Los Angeles Regional Traffic Study (LARTS) which indicates that trip generation rates for automobiles in the Los Angeles area can be correlated with residence type and car ownership. Table 2-1 shows the percentage of sample SDC originally planned to select from each of the criterion groups.

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[1] CRC-APRAC Project Groups CAPE-5 and CAPE-10

Table 2-1. Originally Proposed Stratification of the Sample for the Los Angeles Driving Patterns Survey (Based on 1960 Census Data)

RESIDENCE TYPE	AUTOMOBILES PER HOUSEHOLD	
	ONE	TWO OR MORE
Single Family	45%	17%
Multiple Family	28%	10%

This stratification was based on 1960 Census data. As the study progressed, application forms from prospective participants showed clearly that the present population in Los Angeles has changed markedly from the 1960 population with respect to residence type and car ownership. This change necessitated a modification of the percentages allocated to each of the cells in the matrix in Table 2-1. The final stratification shown in Table 2-2 allocated 31% of the sample to each of the single family dwelling categories. These percentages represent an adjustment to the percentages of application forms actually received (which were more heavily weighted toward single family-multiple car households). The adjustment reflected the probable under-representation of the lower economic strata among those who volunteered to participate in the survey.

Table 2-2. Final Stratification of the Sample for the Los Angeles Driving Patterns Survey

RESIDENCE TYPE	AUTOMOBILES PER HOUSEHOLD	
	ONE	TWO OR MORE
Single Family	31%	31%
Multiple Family	28%	10%

The reason for the stratification was to reflect the varying trip generation rates that LARTS has found to be associated with automobiles in these particular residence type-car ownership configurations. Table 2-3 shows the trip generation rates which we sought to reflect by our stratification scheme.

Table 2-3. Automobile Trip Generation Rates in the LARTS Area (Weekday Passenger Trips Per Vehicle)[1]

RESIDENCE TYPE	AUTOMOBILES PER HOUSEHOLD	
	ONE	TWO OR MORE
Single Family	4.83	3.72
Multiple Family	3.87	3.42

Using these trip generation rates and the stratification shown in the previous table, we estimated that data would be obtained on 4000 weekday trips plus an unknown number of weekend trips for which trip generation rates are not known. This sample size was considered sufficient for estimating mean values of trip variables.

The method by which SDC selected participants in the survey was chosen to obtain a representative cross-section of the overall population as well as to facilitate the scheduling of installation and removal of recording instruments. Business firms in the Los Angeles area were solicited to obtain their participation in the survey. Participating firms circulated application forms among their employees, collected these forms and returned them to SDC, and provided space in which the installation and removal of instruments could be performed. The participation obtained both from firms and from their employees was entirely satisfactory from the standpoint of the survey.

Participants were selected on the basis of the distance they normally drove during a week and the direction from work in which their residence was located. During the survey period 20% of the automobiles were used in a second car mode on one or more days. For cars that were used to drive to and from work, participants were selected in such a way that the sample from any firm reflected the overall driving pattern of all employees in that firm (in terms of distance and direction) as represented by the total number of all applications received. Over 1100 people volunteered to participate in the survey from which number 199 cars were selected for instrumentation. Usable data were obtained from 169 of these.

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[1] Los Angeles Regional Transportation Study, Volume I, Base Year Report 1960, California Division of Highways, 1960; Los Angeles Regional Transportation Study, 1980 Progress Report, Transportation Association of Southern California, 1968

Data were gathered using the Tachograph recording speedometer/odometer. This device makes a continuous eight-day record of the instantaneous speed and cumulative distance traveled by the automobile in which it is installed. In addition, these devices were equipped with a switch that was manually operated by the driver and that indicated on the speed and distance record the type of road over which the automobile was being driven.

In addition to the Tachograph, a log book was placed in each car which the driver filled out for each trip he took. In the log book he indicated information that will be used for various statistical studies in the future related to the dependence of trip variables upon the purpose of trip, road conditions, sex and age of the driver, etc.

The U.S. Weather Bureau provided records of sky cover, precipitation, and temperature conditions that occurred during the sample period.

In addition to the major data collection effort just described, a supplemental survey was made to determine the correlation between the number of momentary stops an automobile makes on various road types and the time actually spent idling. This survey was necessary to amplify Tachograph data (which indicates the number of stops) to idling data. The results of this supplemental survey are discussed under DATA COLLECTION, below.

SAMPLE DESIGN

Specification of the Population Sampled

Basically, any probabilistic sampling plan requires that:

(1) Either explicitly or implicitly, a list of all individuals who comprise the population should be assembled and then,
(2) appropriate randomization mechanisms be used to select samples of the desired probabilistic types from the population.

In survey sampling problems of even modest complexity, one of the most critical issues is the specification of the population. Typically, practical considerations dictate that a population will be used that may differ appreciably from the population that would be ideally suited to the objectives of the study.

In the Los Angeles Driving Patterns Survey the ideal specification of the population would be that of all currently operating cars and their drivers that reside within the area prescribed for the study. If instrumentation, solicitation, driver contact, and other sampling costs were negligible, it would be desirable to obtain the most typical driving patterns for the Los Angeles area from which to draw a simple random sample from this broadly defined population. Sampling costs, however, are not negligible so that these and other factors dictated specification of the basic population used in the study.

The major constraints in selecting the population for study were:

(1) The need to work through large companies,
(2) The need to use volunteer participants, and
(3) Limitations on eligible vehicles.

A basic element of the overall sampling plans required that reasonably large companies be contacted as the first step in obtaining participants. This was necessary from the standpoint of economical use of our instrument installers' time as well as to ensure a large number of volunteers from which to select a sample.

Clearly the particular selection of companies could bias the results that might be expected if drivers were randomly sampled from the "complete" Los Angeles metropolitan driver population. The proximity of companies to freeways, the general wage level of the employees, the extent to which company cars are provided, all these are company characteristics which can effect variables of interest such as average distance driven, trip segment sequences, multiple versus single car ownership in families, the general distribution of models and ages of cars, etc.

The constraints were recognized and the basic list of companies was made as broad as possible. Further, adjustments for the effects of the particular geographic location of the companies were made by selecting a stratified sampling from eight major zones within the Los Angeles area.

In concert with Dr. James Keller of Union Oil, representing the CAPE-5-68 committee of the APRAC, we decided that major emphasis should be placed on determining driving patterns in the so-called "smog belt" of the Los Angeles area. Accordingly, in stratifying our sample geographically, we sought to include somewhat greater representation from companies located in the downtown Los Angeles, East Los Angeles, and San Gabriel Valley areas where the major accumulation of air pollution occurs.

Since relatively little information was available prior to the study concerning relations among the independent variables, strata with equal numbers of sampling units were used. Therefore, no complex weighting scheme was required to estimate the mean values of dependent variables for the total population from the estimates obtained within the various strata.

After the basic list of companies was assembled and stratified samples of companies drawn, a further narrowing of the basic population occurs when volunteers are sought to participate in the study. It is well known that for some types of studies, the responses in terms of volunteers versus nonvolunteers may have quite different distributions. In the present study, however, it would seem unlikely that willingness to participate would have any significant effect on the results. Vacation and other scheduling conflicts among the volunteers also resulted in elimination of some potential participants. In addition, failures to keep usable log books by a few participants, mechanical difficulties with some of the Tachograph units, and mechanical difficulties with a few of the participating automobiles were of sufficient severity as to require elimination of some data.

Finally, there were many makes and models of automobiles for which it would be very difficult and expensive to install the Tachograph instruments. Among cars which were excluded for this reason were all foreign makes except Datsuns and 1967-68 Volkswagens. Among cars manufactured in the United States, all cars with 6-volt electrical systems were excluded: Continentals, Corvettes, Cougars, Dodges prior to 1966, Mustangs, Oldsmobiles, Thunderbirds, and several other specific year-models were excluded. Furthermore, all station wagons and trucks were eliminated because it had been decided earlier that only in-trunk installations of the main recording unit of the Tachograph system would be made.

More than 1100 volunteers from twelve different companies survived the filtering effects on the broad definition of the survey population due to the restrictions on selection of companies and then on volunteers within companies. Application forms from two companies were returned too late to permit these volunteers to participate in the study. Selections were finally made from a set of 1076 volunteers. Information in the application forms from these volunteers lead to the elimination of 521 individuals due to the unsuitability of their automobiles or scheduling conflicts. From the remaining 555 subjects, a sample of 199 was chosen. Tachograph failures and totally incorrect log book entries required the complete elimination of records of 30 more cases. Thus, the analyses for the Los Angeles study are based upon results for a sample of 169 drivers.

SAMPLE SELECTION

The Multi-Stage Sampling Process

The sampling plan for the Los Angeles area survey was a multi-stage process consisting of two main stages:

(1) Stratified, cluster sampling from the basic list of companies. The stratification refers to the geographic dispersal of the companies whereas each company constitutes a cluster of the ultimate sampling unit, the car and driver.

(2) Stratified sampling on (a) family classification according to numbers of cars and type of dwelling, and (b) distance and direction driven to work.

The information that was used as a basis for part (a) of the stratification in the second stage of sampling was derived from 1960 U.S. Census data for the area. In the early stages of the survey, however, as questionnaires from volunteers were received, it became clear that considerable shifting in dwelling and car ownership characteristics had occurred since that time. It was true, of course, that each company represented a distinct subpopulation whose car ownership/dwelling characteristics need not necessarily reflect the same characteristics in the population as a whole. However, the uniformity in direction and magnitude of the shifts as indicated in the questionnaires received from all the companies convinced us that the proportions indicated by the 1960 Census data were no longer representative of the entire population. The adjusted proportions finally arrived at represent a compromise between the 1960 Census data and the actual proportions reflected by the questionnaires.

This compromise was decided upon in order to reflect the possibility of subpopulation not being completely representative of the overall population.

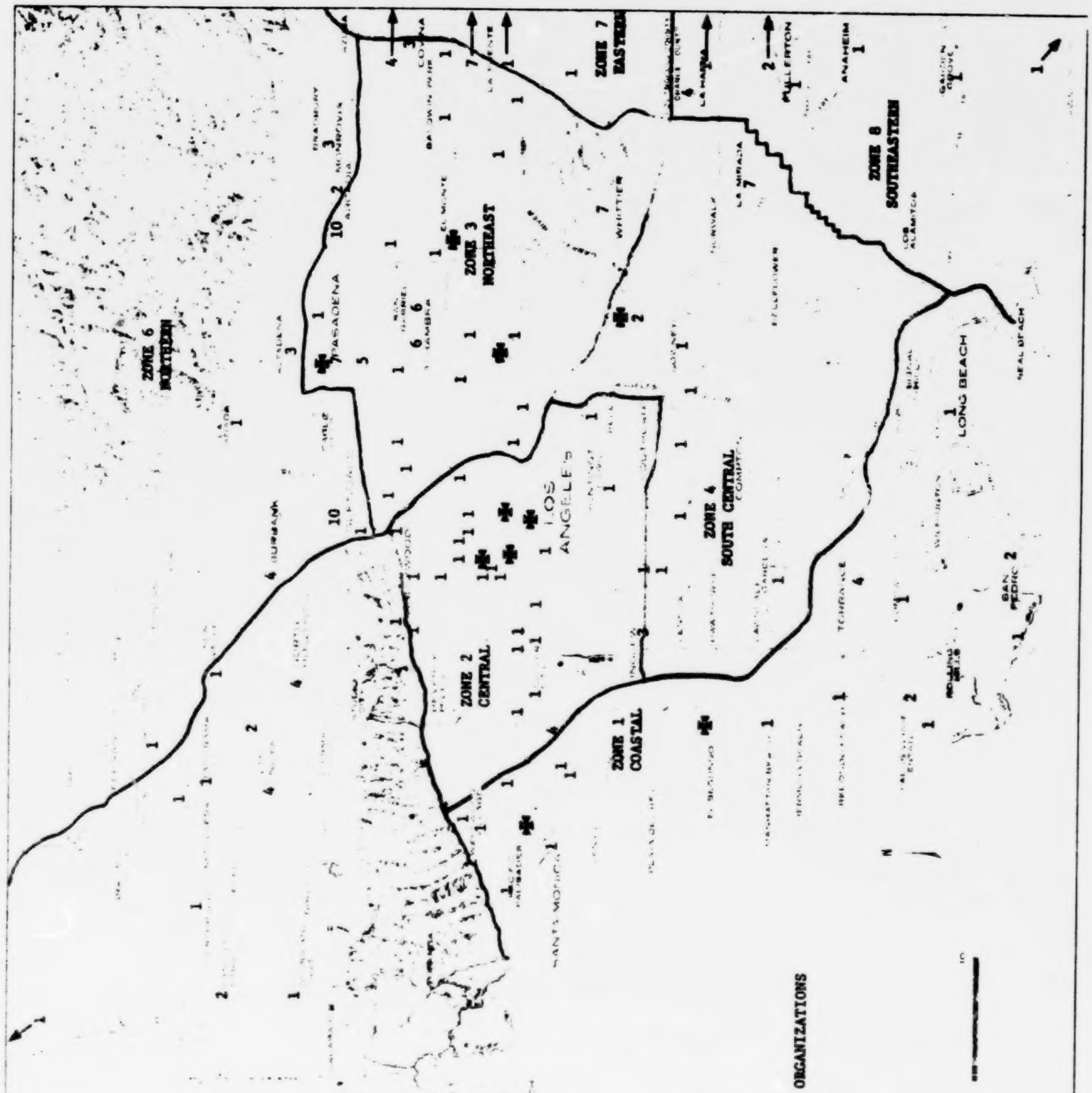
Selection of participants on the basis of direction and distance of travel to work--part (b) of the second stage sampling--was made to reflect the overall pattern of such travel as indicated by the questionnaires received from each company.

The geographical distribution of volunteers by residence location is shown in Figure 2-1.

DATA COLLECTION

The data collection effort began in June with recruiting of survey participants from among SDC employees. SDC was chosen for the first installation to allow project personnel to gain experience in installing the Tachograph instruments as well as to check out volunteer questionnaires, prototype log books, etc. A request for volunteers was made to all personnel at the Corporation's Santa Monica facility by means of the SDC Bulletin, a weekly in-house publication distributed to all employees. One hundred and thirty-six individuals responded to the request from which 24 were chosen as the SDC survey sample. Installation of the Tachographs began on June 18, 1968.

To obtain volunteers from other organizations, SDC personnel met with a representative of the Los Angeles Area Chamber of Commerce who provided a list of 15 organizations located in areas determined by sample design, and each was asked to solicit volunteer participants from among its employees. Of the 15 organizations contacted, seven agreed to participate--Occidental Life Insurance Company of California, Bank of America, Union Oil Company, North American Rockwell Corporation, Southern Counties Gas Company, Consolidated Electrodynamics Corporation, and Aerojet-General Corporation. In addition, the Chamber of Commerce volunteered to solicit participants from its own staff as did the California Spring Company which had learned about the survey from the Chamber. These two organizations, plus SDC, brought the total number of participating organizations to ten.


ZONE 1 COASTAL
ZONE 2 CENTRAL
ZONE 3 NORTHEAST
ZONE 4 SOUTH CENTRAL
ZONE 5 WESTERN
ZONE 6 NORTHERN
ZONE 7 EASTERN
ZONE 8 SOUTHEASTERN
✚ - PARTICIPATING ORGANIZATIONS
PASADENA
BURBANK
LOS ANGELES
COMPTON
WHITTIER
LA MIRADA
NORWALK
FULLERTON
ANAHEIM
LONG BEACH
SEAL BEACH
TORRANCE
SAN PEDRO
SANTA MONICA
MALIBU BEACH
SYSTEM DEVELOPMENT CORPORATION
2500 COLORADO AVENUE
SANTA MONICA CALIFORNIA

NOT REPRODUCIBLE

FIGURE 2-1

RESIDENCE LOCATION OF VOLUNTEER PARTICIPANTS

Each organization was contacted initially by letter. Those agreeing to participate were then visited by an SDC representative who explained the objective of the survey in greater detail. Also, each organization was provided with information/questionnaire packets for distribution to prospective participants. Each packet contained a brief description of the purpose of the survey as well as a questionnaire to be completed by anyone wishing to participate. (See Appendix 1).

All the organizations were encouraged to seek as many volunteers as possible; however, the number to be solicited as well as the method to be used to distribute the information/questionnaire packets was left to the discretion of each organization. Generally, those organizations with a small staff (85 to 500 people) chose to canvas all of their employees for volunteers. Those with a larger staff (more than 500 people) decided upon some form of random method of distribution, i.e., distribute one packet to every third name in the telephone book, distribute packets to all personnel who parked their automobiles in the company garage, etc. The one exception was the Union Oil Company which chose to distribute packets to all 1300 of their employees.

A total of 5720 packets were distributed within the participating organizations. Of that number, 1076 individuals volunteered to participate from which 199 were chosen as the survey sample (see Table 2-4).

Survey Data

The driving pattern data were collected by means of Tachograph automatic recording devices and log books maintained by the drivers of the automobiles. Each Tachograph recorded the driving data of an automobile on a set of eight discs, each disc containing the record of a single day's driving (the discs were automatically changed at midnight each day). Data were recorded by a set of four styli traveling over the wax surface of the disc. One stylus, activated whenever the vehicle's engine was running, indicated velocity when

TABLE 2-4

RECRUITING PARTICIPANTS

Organization	Questionnaires Distributed	Volunteers	Survey Sample
System Development Corporation	2000	136	24
Occidental Life	350	176	26
Bank of America	550	201	28
California Spring Company	120	36	12
Consolidated Electrodynamics	400	171	29
Aerojet-General	400	66	26
Southern Counties Gas Company	200	59	10
North American Rockwell	300	38	6
Union Oil Company	1300	174	30
Chamber of Commerce	100	19	8
TOTALS	5720	1076	199

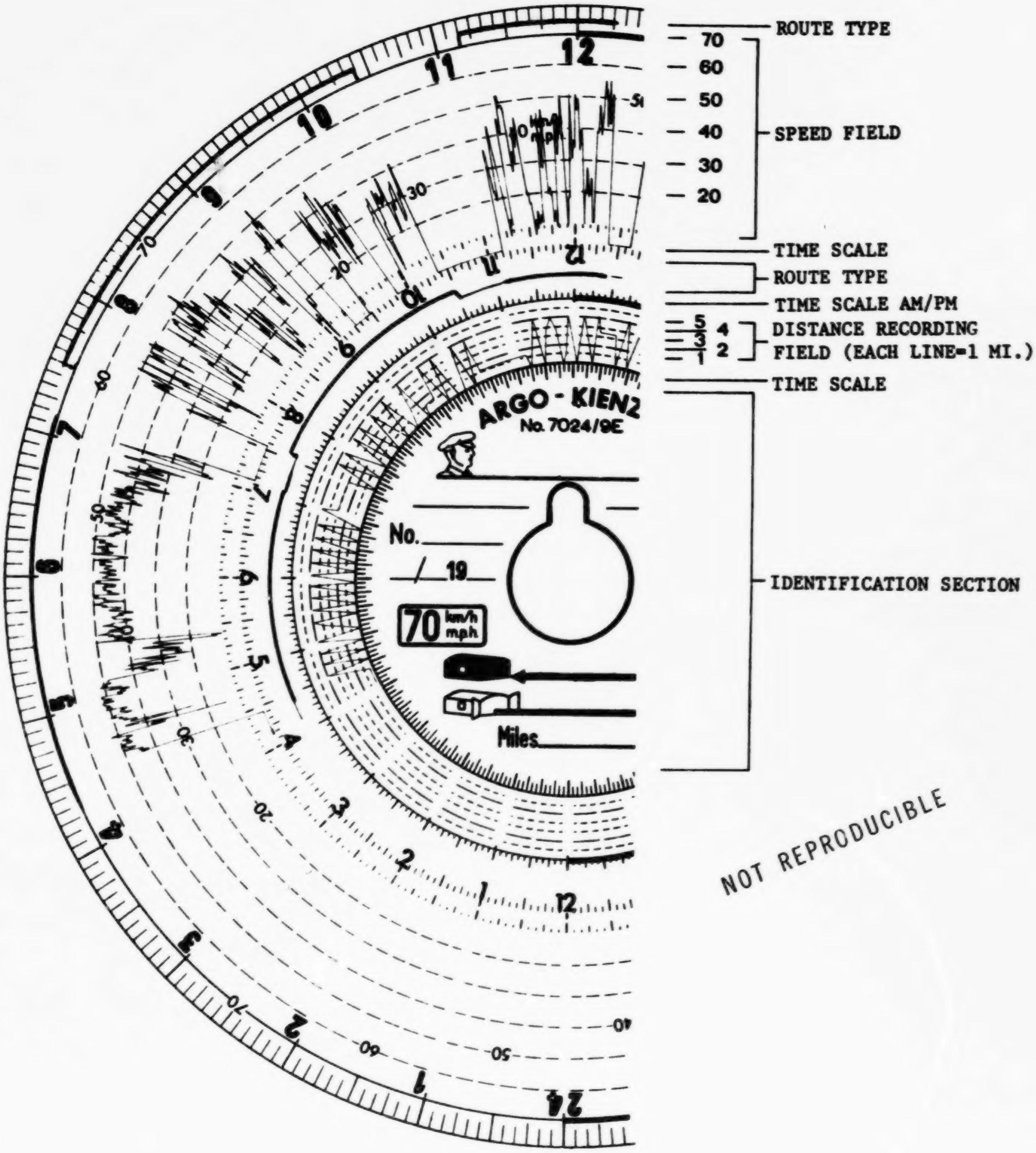
the car was moving as well as engine idling when the car was stopped. A second stylus recorded distance traveled whenever the automobile was moved. The third and fourth styli, operating in conjunction with each other and activated by the driver by means of a dash-mounted switch, indicated the type of route (stop and go, arterial, or freeway) over which the car was being driven. All of the data indicated on the discs were recorded in actual time (see Figure 2-2).

The log books provided automobile and driver information (make, model, year, etc., of car, and name, address, age, sex, etc., of each driver of the car) as well as supplementary data in coded form for every trip made each day specifying driver, zone and location at trip start, purpose of trip, trip start time, route type switch error, road conditions during the trip, inside or outside parking at end of trip, and the fuel gauge reading at the beginning of the day. The start time entries in the log book were obtained for correlation purposes to reconcile any discrepancies that might exist between log book entries and data recorded on the discs (see Figure 2-3).

Stop/Idling Data Survey

The Tachograph data record does not suitably provide data on idling time because the velocity trace is too closely packed to enable the desired data to be read. The number of stops can be counted and/or estimated with reasonable accuracy, however. It was decided, therefore, to count the number of stops in each trip segment and use a mathematical model of some sort to convert the resulting number to idling time. In order to develop the required mathematical model, a series of test runs with SDC corporate cars was made to gather data from which to determine idling time as a function of the number of stops and the type of route.

The length of stops in excess of 40 seconds can be measured using the Tachograph record. Therefore, the test runs were concerned only with stops of duration shorter than 40 seconds. Seven test runs were made. These runs


ROUTE TYPE
70
60
50
40
30
20
SPEED FIELD
TIME SCALE
ROUTE TYPE
TIME SCALE AM/PM
5
4
3
2
1
DISTANCE RECORDING FIELD (EACH LINE=1 MI.)
TIME SCALE
IDENTIFICATION SECTION
ARGO-KIENZ
No. 7024/9E
No.
/ 19
70 km/h mph
Miles

NOT REPRODUCIBLE

FIGURE 2-2

TACHOGRAPH DISC

FLIP YOUR SWITCH!

________________Day

Fuel Gauge E ___ 1/4 ___ 1/2 ___
3/4 ___ F ___

	Before Trip				After Trip				
Trip Number	Driver	Starting Place Zone	Starting Place Location	Purpose of Trip	Start Time	Switch Error	Road Conditions	Park In	Park Out
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									

SAMPLE

Location Code

Home	H
Place of Employment	W
Business Related	B
Shopping Area, Dr. Office, etc.	S
School	E
Recreational	R
Other (specify on Log)	

Purpose of Trip

Go Home	H
Go to Work	W
Business Related	B
Shopping, Doctor, Lawyer, etc.	S
School Related	E
Recreational	R
Other (specify on Log)	

Road Conditions

Dry	D
Wet	W
Icy	I

FIGURE 2-3

LOG BOOK DAILY TRIP SHEET

were divided into 18 trips as defined for the study. The trips consisted of 63 trip segments. Of these, 28 segments were on stop and go streets, 24 on arterial streets, and 11 on freeways.

Because a trip with no stops would have no idling time whereas a trip with many stops would accumulate a great deal of idling time, it was reasonable to expect that a regression model, linear or nonlinear, would result in a realistic approximation of the model that was desired for converting stop counts to idling time. Figure 2-4 shows a scatter diagram of the idling time in seconds accumulated during momentary stops as a function of the number of such stops during the test runs. Also shown are the linear approximations to these functions given by the general formula:

$$T_{I_j} = a_j N_s + b_j$$

where: T_I = estimate of total idling time accumulated during momentary stops on $j^{\underline{th}}$ road type;

N_s = number of momentary stops on $j^{\underline{th}}$ road type;

a_j, b_j = linear regression coefficients for $j^{\underline{th}}$ road type obtained from the formulas:

$$a_j = \frac{N_j \Sigma xy = \Sigma x \Sigma y}{N_j \Sigma x^2 - (\Sigma x)^2}$$

$$b_j = \frac{\Sigma y \Sigma x^2 - \Sigma x \Sigma xy}{N_j \Sigma x - (\Sigma x)^2}$$

where: x = number of stops during a particular segment or a particular road type;

y = amount of time (in seconds) accumulated in momentary stops during the same segment;

N_j = number of segments driven on the $j^{\underline{th}}$ road type during the test run period.

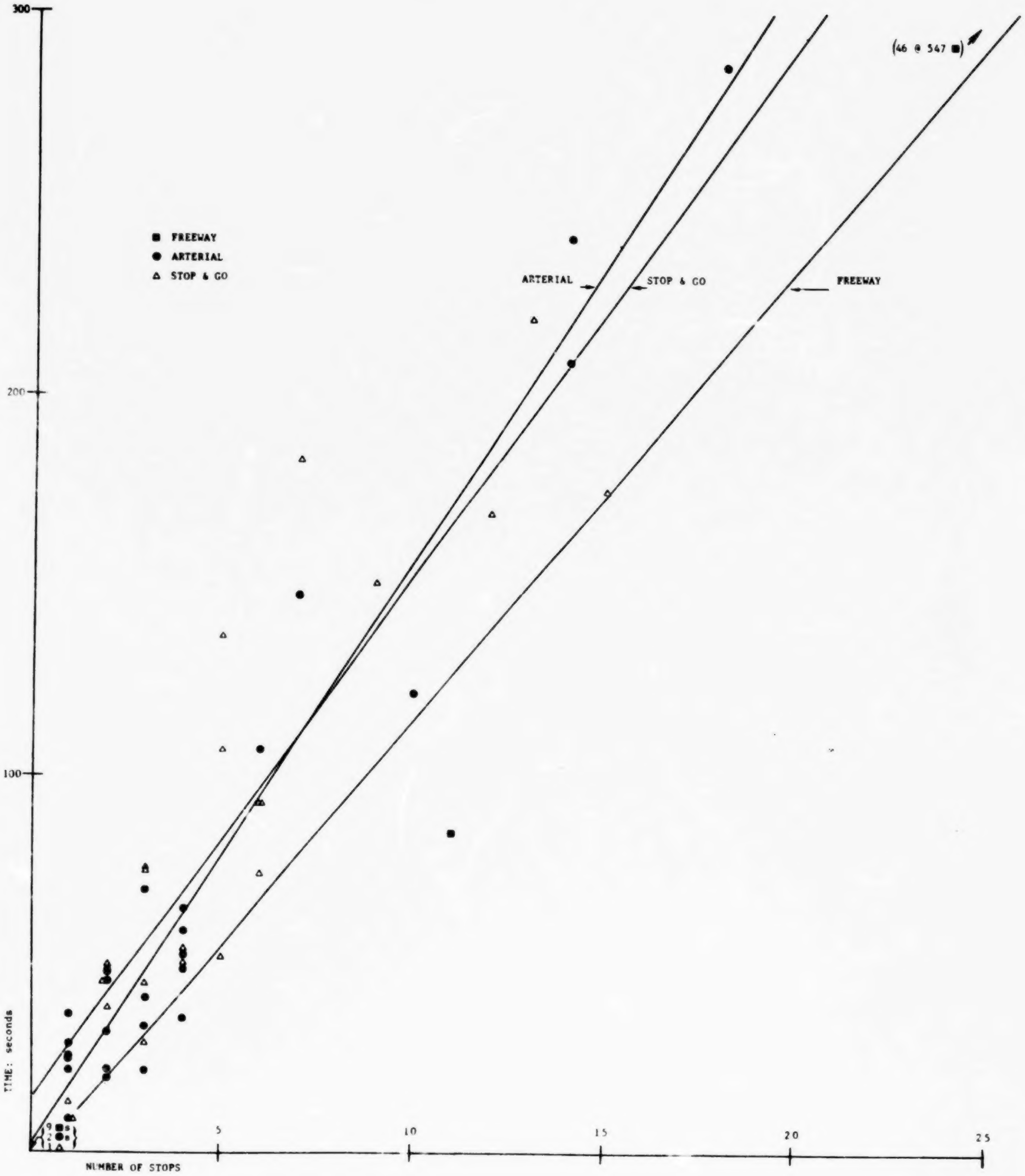


FIGURE 2-4

SCATTER DIAGRAM:

IDLE TIME VERSUS NUMBER OF STOPS

Table 2-5 shows the linear regression coefficients for each road type.

TABLE 2-5. Linear Regression Coefficients for Each Road Type Derived from Data Obtained During Test Runs in Los Angeles

ROAD TYPE	LINEAR REGRESSION COEFFICIENTS A	B
Stop and Go	13.9	14.0
Arterial	15.5	1.3
Freeway	11.8	-3.4

As can be seen from the scatter diagram, linear regression provides as good a fit to the data as can be expected. Values lie to each side of the approximations for all values of the independent variable and there is no clustering that would indicate that a better fit was available from any higher form of regression model. However, because of the wide scatter of data points around the regression lines it is clear that the model provides only a rough approximation to the empirical data. Consequently, we are unable to attach as much confidence to this portion of the survey data as we would like and must urge the reader to use values of idling time obtained from this model with caution.

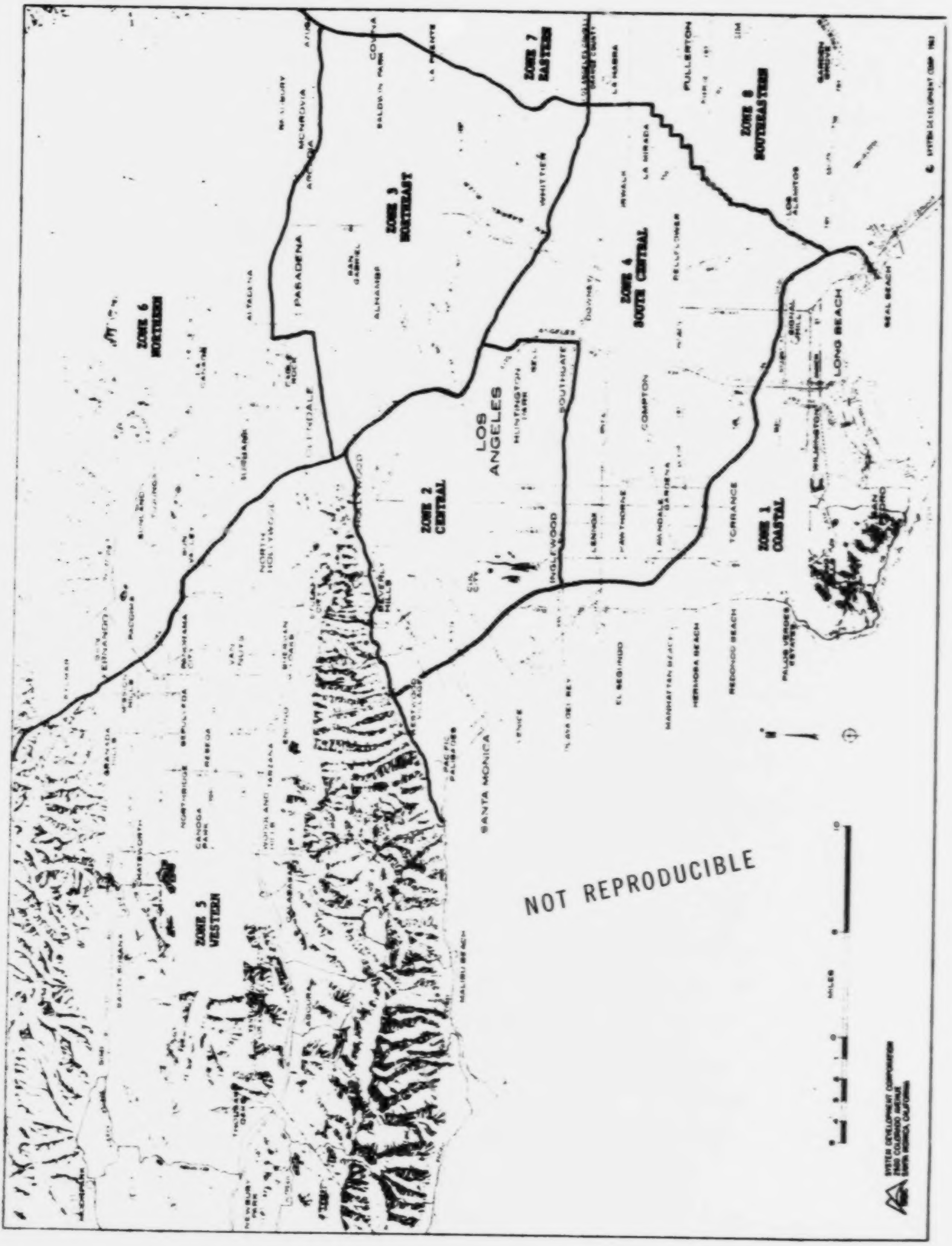
It is interesting to note that the difference between stop and go and arterial road types as a determinant of idling time during momentary stops is very slight. Indeed, the slopes of the approximating lines differ by less than one degree, and the lines cross in the vicinity of nine stops. Freeways, on the other hand, show a marked difference from the other two road types. It was found that in most test runs, no momentary stops were experienced on the freeway even though traffic was sufficiently dense to require a substantial decrease in the average velocity of the car. In only two of the eleven freeway segments were any momentary stops experienced and these were in periods of extremely heavy traffic.

Weather Data

In order to enable the correlation of trip variables with weather and road conditions at a later time, if desired by any of the Project Groups of CRC-APRAC, it was necessary to develop a data base describing the weather conditions that prevailed during the survey period. Road conditions for each trip were indicated by the driver in his log book. Official U.S. Weather Bureau sources were used for the weather data base. Because sky cover and precipitation and/or obstruction to vision data were required as well as temperature data, it was decided that aviation weather observations were the only appropriate source. These observations, made hourly at several locations in the Los Angeles area, are retained at the U.S. Weather Bureau office in Los Angeles in the form of Forecaster Verification forms which are used by the Weather Bureau to correlate forecasts with actual observations.

Aviation weather observations from four locations were available from the Los Angeles office of the Weather Bureau. These locations are Los Angeles International Airport, Long Beach Municipal Airport, Lockheed Air Terminal at Burbank, and Van Nuys Airport. The first three stations report complete weather data. Van Nuys Airport does not report temperature readings. A fifth source of data was the records of the Los Angeles Air Pollution Control District for temperature in the downtown Los Angeles area. These observations are made hourly but no records of sky cover, precipitation, or obstruction to vision are made concurrently.

Because of the large size of the Los Angeles study area it was necessary to associate the various weather observations with particular geographic areas. Particular observations or portions of observations were therefore associated in the data base with the zones into which the study area was divided. These zones are shown on Figure 2-5. Table 2-6 shows the observations source for each of the three elements in the weather data base for each of the three Los Angeles area zones.


ZONE 1 COASTAL
ZONE 2 CENTRAL
ZONE 3 NORTHEAST
ZONE 4 SOUTH CENTRAL
ZONE 5 WESTERN
ZONE 6 NORTHERN
ZONE 7 EASTERN
ZONE 8 SOUTHEASTERN
LOS ANGELES
PASADENA
ALHAMBRA
SAN GABRIEL
ARCADIA
MONROVIA
BALDWIN PARK
COVINA
LA PUENTE
WHITTIER
ALTADENA
GLENDALE
BURBANK
NORTH HOLLYWOOD
BEVERLY HILLS
CULVER CITY
INGLEWOOD
HUNTINGTON PARK
SOUTHGATE
DOWNEY
BELLFLOWER
NORWALK
LA MIRADA
LA HABRA
FULLERTON
LOS ALAMITOS
GARDEN GROVE
SEAL BEACH
LONG BEACH
WILMINGTON
SAN PEDRO
COMPTON
GARDENA
HAWTHORNE
LENNOX
LAWNDALE
TORRANCE
REDONDO BEACH
HERMOSA BEACH
MANHATTAN BEACH
EL SEGUNDO
PLAYA DEL REY
VENICE
SANTA MONICA
PACIFIC PALISADES
MALIBU BEACH
PALOS VERDES ESTATES
SAN FERNANDO
PACOIMA
SUN VALLEY
VAN NUYS
SHERMAN OAKS
ENCINO
TARZANA
WOODLAND HILLS
CANOGA PARK
RESEDA
NORTHRIDGE
SEPULVEDA
PANORAMA CITY
GRANADA HILLS
CHATSWORTH
NEWBURY PARK
MILES
SYSTEM DEVELOPMENT CORPORATION
2500 COLORADO AVENUE
SANTA MONICA CALIFORNIA

NOT REPRODUCIBLE

FIGURE 2-5

LOS ANGELES DRIVER PATTERNS SURVEY

SURVEY ZONES

Table 2-6. Sources for Weather Data Base Elements for Los Angeles Area Zones.

ZONE	SKY COVER	PRECIPITATION OR OBSTRUCTION TO VISION	TEMPERATURE
1	LAX	LAX	LAX
2	LAX	LAX	APCD
3	BUR	BUR	APCD
4	LGB	LGB	LBG
5	VNY	VNY	BUR
6	BUR	BUR	BUR
7	BUR	BUR	APCD
8	LGB	LGB	LGB

Abbreviations:
LAX--Los Angeles International Airport
LGB--Long Beach Municipal Airport
BUR--Lockheed Air Terminal
VNY--Van Nuys Airport
APCD--Los Angeles Air Pollution Control District

PART III

DATA REDUCTION AND STATISTICAL ANALYSIS

DATA REDUCTION

Once collected in the form of Tachograph discs and log books, the basic data enter the data reduction process. Essentially, this process converts the coded and analogue-recorded data to digital form, processes it, and produces a readily understandable record for each trip taken by survey participants during the survey period. Reduction of the data involves manual, machine-assisted, and computer-programmed processes. Seven steps make up the data reduction portion of the driving pattern study:

1. Manual Processing of Discs and Log Books
2. Manual Conversion of Weather Data
3. Tachograph Trace Plot
4. Data Edit and Card-to-Tape
5. Error Correction
6. Data Conversion
7. Data Base Printout

Manual Processing of Discs and Log Books

The first step in the manual data reduction consists of manuscripting the automobile and driver identification information as recorded in the log book onto a prepared keypunch form known as the Automobile Identification Record. Such information as the participant's name, address, and employer, and the automobile make, year, model, and license number are included in this record.

Next, each Tachograph disc--the record of one day's driving--is examined to ensure that the distance, route type, and velocity traces are complete. If any one of the traces are missing or incomplete, the disc is considered unusable and that day eliminated from the survey. Each disc is then compared with the log book to determine if the data entered in the log book match that recorded on the disc. If there are inconsistencies, steps are taken to reconcile them. Typical discrepancies include different numbers of trips on the log book and on the disc, and start times for trips in the log book that do not coincide with actual start times as indicated on the disc. The first type of discrepancy is often reconciled when close examination of the disc shows that a single trip record really represents two trips separated by an inter-trip time of less than five minutes. Discrepancies of the second type, if they show no consistent pattern, are resolved by accepting the disc start time as the real one. If, on the other hand, there is a consistent pattern of time error between log book and disc, a time correction factor is entered into the record which is used in later processing to adjust the times on the disc.

If discrepancies between the log book and the disc cannot be reconciled, the day is eliminated from the survey. In order for this to occur, the amount of missing data must be such as to preclude a valid definition of the day's driving pattern.

Once the data in the log book and on the disc are judged compatible, information from both sources is recorded onto another keypunch form called the Trip/Stop Record. This record contains information to identify each particular trip and segment, the zone and type of location associated with the departure and arrival points of the trip, the purpose of the trip, the type of parking location at the end of the trip, and the number of momentary stops made in each segment of the trip.

The technician counts the number of momentary stops with the aid of a Tachograph Chart Analyzer which provides a four-fold magnification of the physical disc itself. At this time, the disc is also marked to indicate trip and segment numbers, and route types (i.e., the type of road used for each trip segment). These marks are used to insure consistency between the manual data reduction and the semi-automatic Tachograph Trace Plot reduction described below.

At the conclusion of this step, the data from the Automobile Identification Record and the Trip/Stop Record are keypunched onto cards and held for later processing in the data edit and card-to-tape phase.

Manual Conversion of Weather Data

After the sky cover, precipitation, and temperature data are obtained from U.S. Weather Bureau Records, the information is coded for the city, zone, project day number, and time of day (one hour intervals) and entered on a prepared keypunch form known as the Weather Record. The data are coded as follows:

Sky Cover Data

0 - Clear
1 - Scattered
2 - Broken
3 - Overcast
4 - Obscuration

The heaviest existing sky cover for a particular hour is always indicated.

Precipitation and Obstruction of Vision

Fog	1, if visibility was two miles or less, otherwise 0
Ground Fog	
Ice Fog	
Haze	
Smoke	
Dust	
Blowing Dust	
Blowing Sand	
Blowing Snow	
Drizzle	2
Thunderstorm	3
Hail	
Rain	
Rain Showers	
Freezing Rain	4
Freezing Drizzle	
Snow	
Snow Showers	
Snow Pellets	
Snow Grains	
Ice Crystals	

To indicate heavy or light precipitation, the sky cover information is preceeded by a plus (+) or minus (-).

Temperature information is recorded directly in degrees farenheit for each hour.

Tachograph Trace Plot

This phase of the data reduction process involves the use of a Computer Industries, Inc., Model 29E Film Reader to plot the X-Y coordinates of selected points on the Tachograph traces. Pictures of each Tachograph disc are made on 70 mm film. The film is loaded into the Model 29E and projected onto a viewing surface. Vertical and horizontal crosswires are positioned so that their point of intersection lies over a selected point on the trace. The point selected by the operator is one of a sequence of points which together enable the computer to reconstruct the data traces on the disc. The X-Y coordinates of the point relative to a calibrated origin in the center of the Tachograph disc are then punched automatically into a computer card. Related data identifying the Tachograph disc by car and date, trip number, type of trace with which the point being plotted is associated, and sequence number of the point are also entered into the computer card by setting various counters on the Model 29E equipment.

Four types of cards are punched during this phase of the processing. For each Tachograph disc six calibration points are plotted that enable subsequent computer programs to determine the angular span of the 24-hour period on the disc, the amount of radial distance that represents five miles on the distance trace, and any phase difference that may exist between the distance and velocity traces on the disc. X-Y coordinates of all points along the distance trace where its slope changes (points of inflection) are plotted in order from the starting point of the point where the engine is turned off. Next the operator punches the X-Y coordinates of those points along the route-type traces where changes occur. A code for the route type is included in these cards in order to correlate the route-type change points with the segment stop cards prepared as part of the manual reduction process. Finally, the operator punches the X-Y coordinates for pairs of points representing the beginning and end points of measurable idling periods. Measurable idling periods are shown by a pronounced widening of the velocity trace.

Having completed one trip, the operator moves on to the next trip punching cards in the same order: (1) distance trace points, (2) route-type change points, and (3) measurable idling period beginning and end points. When all trips for the day are complete, the operator advances the film in the film reader, punches the calibration cards for the next disc, and processes the trips in order as before.

The cards that are output from this process are combined with the cards from the manual data reduction step previously described and are input to the data edit and card-to-tape step described in the next section.

Data Edit and Card-to-Tape

As the first step in this phase of processing, punched cards prepared during the manual and Tachograph trace plotting reduction processes are sorted to merge the data representing each automobile. The cards are checked for errors in both the manual transcription of log book data and the operation of the Telereadex equipment on an IBM 360/67 computer program which verifies the cards for completeness and for logical progression and cohesion within the framework of the automobile, day, trip, and trip segment hierarchy. The result of this error check process is a printout showing the data contained on each punched card and, if an error in the card is detected, a message indicating the nature of the error. These printouts are used later in the error correction process described in the next section.

In addition to checking errors, the computer program condenses the data on the punched cards and transfers these condensed records to magnetic tape for input to the subsequent data conversion program. Condensation of the data is possible since by stringing together all the X-Y coordinates associated with a particular Tachograph trip trace, identification and sequencing information contained on each X-Y coordinate card only has to be repeated at the beginning of each string. The use of magnetic tape for input to subsequent programs not only makes the use of larger logical records possible, it also means that less input time is used in the remaining computer processing.

The data edit and card-to-tape process is an interactive one with input to and feedback from the error correction process. Because of the size of the data base, approximately 80,000 punched cards for Los Angeles, several passes through the programs followed by error correction are required before the data are completely error free as determined by the editing program. Physical accuracy of the Model 29E equipment as well as certain limitations inherent in the Tachograph result in some errors remaining undetected until the data conversion program is run. The detection and handling of these errors is treated in the description of the data conversion program.

Error Correction

Logical errors in the punched card data base are detected by the edit and card-to-tape program, and a printout showing these errors is output by the computer. Typical errors are failure to include all trip information in the trip cards, an insufficient number of distance trace cards for a trip, failure to prepare the proper number of route-type change cards to match the number of segments in the trip, etc. In correcting these errors, data analysts are required to purge the cards containing errors from the deck and reprocess the data from log books and discs either manually or with the assistance of the Model 29E. The new cards are then sorted into the data base and rerun through the edit and card-to-tape program. As mentioned above, several iterations between the program and the error correction are required because of the large size of the data base.

Data Conversion

Once free of errors, the data base tape, prepared in the data edit and card-to-tape phase, is input to a data conversion program. This program converts the X-Y coordinates associated with the various Tachograph trace points into time and distance information that recreates the analogue record of the Tachograph in a digital format.

During this conversion process, the program detects additional errors that slipped through the logic checks in the edit and card-to-tape program. These errors are detected as anomalous progressions in time between adjacent trace plot points. There are three major causes for such errors: 1) random errors in the data base card deck caused by equipment malfunction or operator error, 2) non-synchronization between the route type trace styli and the distance trace styli, and 3) inability of the Model 29E Film Reader to resolve data points sufficiently so that the operator can insure that adjacent points progress properly in time. The program is designed to make approximations and/or other types of resolutions when it detects such errors.

The program also interprets and converts log book and manually reduced stop data into a format suitable for subsequent use by statistical analysis programs. Stored weather data are examined and the sky cover, precipitation conditions, and temperature prevailing at the time of each trip are entered into the trip record. Files are prepared containing all available information on each trip. These files are then processed by a program that formats the data properly and prints it out as a permanent record of the data base, and then performs a series of statistical analyses that reduce the data into a format from which typical driving patterns can be derived.

Data Base Printout

Records prepared by the data conversion program are formatted and printed out by a third program. Data in the printout are ordered by automobile. At the start of each automobile record, the printout contains one line of information identifying the car and owner. Following this is the trip and trip segment information arranged under column headings that are self-explanatory. The first line in each group contains summary information on each trip. Following this are lines containing segment information, one line for each segment.

Figure 3-2 is a flow diagram of the data reduction and analysis process.

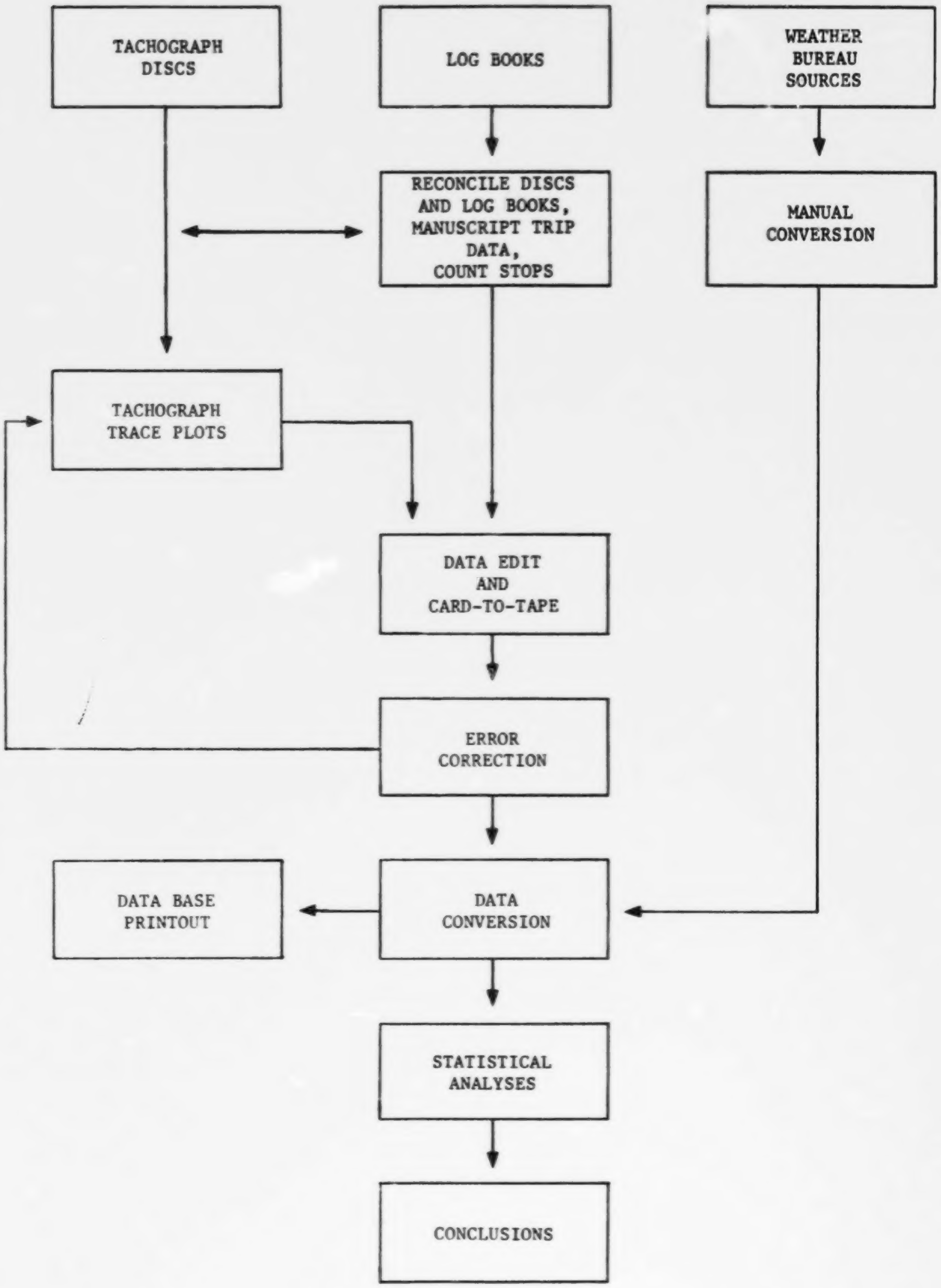

TACHOGRAPH DISCS
LOG BOOKS
WEATHER BUREAU SOURCES
RECONCILE DISCS AND LOG BOOKS, MANUSCRIPT TRIP DATA, COUNT STOPS
MANUAL CONVERSION
TACHOGRAPH TRACE PLOTS
DATA EDIT AND CARD-TO-TAPE
ERROR CORRECTION
DATA BASE PRINTOUT
DATA CONVERSION
STATISTICAL ANALYSES
CONCLUSIONS

FIGURE 3-1
DATA REDUCTION AND ANALYSIS
FLOW DIAGRAM

A different data record is prepared for input into the statistical analysis routines. This record, stored on tape, contains amplifying data on each trip and segment to assist in classifying the individual records for more effective processing. The individual record for each trip contains at least 54 separate data items. If the trip has more than one segment, there are 21 additional items for each segment. In the Los Angeles study, there are 4901 trip records.

Statistical Analysis

The next phase in the data reduction and analysis procedure involved further processing of the complete records according to well known principles of statistical inference. Standard programs in SDC's statistical analysis program library were used to carry out the analyses. In addition, several special purpose programs were written to analyze frequencies of occurrence of transitions from trip-to-trip under various conditions.

Computer-Based Statistical Analyses

The main objective in this survey was to obtain more detailed descriptions of driving patterns than have been available from other studies. At this stage in research on driving patterns, well-defined hypotheses have not been formulated to be put to statistical tests. Consequently, the primary theme of the statistical analyses was to determine useful descriptive statistical summaries of the detailed results of this survey. It will be desirable at future stages to examine the form of the distributions of the data so that confidence interval and confidence set statements can be developed to supplement the descriptive statistics derived in these analyses. Such further analyses will be helpful in the formulation of composite driving patterns descriptive of a broad range of driving habits.

Three principal types of analyses were carried out: (1) computation of frequency distributions for qualitative variables and for various quantitative dependent variables that had been classified into suitable intervals,

(2) computation of contingency tables for qualitative variables to allow examination of joint frequencies of occurrence, and (3) computation of sample means and standard deviations for quantitative variables to reveal typical values for distributions and the dispersion or variability of values in these distributions.

Frequency Distributions

The general information sought through frequency distribution computations was of three main types. One feature of great interest was whether the distributions were of single or multi-modes (or at least, whether several "peaks" of frequencies appeared at separate places in the distributions). A related feature of interest was the general shape of the distributions (monotonic decreasing, mound-shaped but skewed or asymmetric, mound-shaped and symmetric, etc.). Finally, the computation of the frequency distributions provided information to check on extreme, outlying scores.

Some of these outlying scores represented clearly unrealistic data that was caused by errors in the data reduction and conversion process. For example, on a short trip it does not require much error in elapsed time over the distance to come up with an average speed of say 125 miles per hour, clearly an unrealistic value. In the ensuing statistical runs, such unrealistic values had to be eliminated to avoid biased results. Therefore, in the case of average speed, all values in excess of 70 miles per hour were discarded. The values for distance and elapsed time for such trips were not, however, discarded. As a result, the number of cases treated in the analysis is not consistent from variable to variable.

Additional data were discarded to meet computer program limitations with respect to data storage. Results calculated on each trip for distance, elapsed time and average speed were for all practical purposes continuously distributed. In order to continue the statistical analysis, it was necessary to partition these variables into certain class intervals and use the midpoint of these intervals in further computations. As a result, while each mean value for the class interval is accurate, these three variables are no longer functionally related in the exact sense. (Mean values are not affected by classification; variances and higher moments are.) In the class interval structure, outlying data above certain arbitrary values, always less than one percent of the total data, were treated as blanks and not incorporated into the subsequent calculation of means and variances. The arbitrary upper limits imposed were as follows:

Distance: 50 miles
Elapsed Time: 2 hours
Average Speed: 70 miles per hour

As a result of these limits, there were 43 distance values (0.9%), 20 elapsed time values (0.4%), and 44 average speed values (0.9%) discarded. The percentages shown are of the total number of 4901 trips.

The distribution of numbers of trips per day was one of the frequency distributions computed that was central in importance for guiding other types of analyses in the study. For many of the quantitative dependent variables of the study, we had frequency distributions computed for class intervals of these scores after inspection of preliminary results suggested reasonable ranges of these scores. Some extreme scores were removed in this process either because inspection of the complete data records clearly demonstrated that values were not valid or by other technical considerations the scores could be classified as outlying, extremely unusual cases.

Qualitative Variables - Contingency Table Analyses

A number of the independent variables studied in the survey were environmental characteristics of a qualitative nature. We used programs for evaluation of contingency tables to obtain information about frequency of occurrence of trips as a function of these kinds of qualitative independent variables. Programs for contingency table analysis allow the possibility of examining statistical hypotheses such as the statistical independence of the variables of classification. Although the hypothesis of independence was not of interest here since it is well known that strong dependencies may be expected among the qualitative variables considered, the results of testing for independence did provide an indication of the degree and direction of dependence existing between the variables.

We had frequencies and relative-frequencies (percentages) of trip occurrences computed against the cross-classification of four variables:

a. Type of day (weekday or weekend).
b. Purpose of trip (six purposes were identified).
c. Trip segment string (segment strings were identified in terms of the route types that drivers indicated for the successive segments for the trip). For this analysis, we grouped the segment sequences into the four classes:

    1. Nonfreeway
    2. Nonfreeway-freeway-nonfreeway
    3. Nonfreeway-freeway-nonfreeway-freeway-nonfreeway
    4. All others

d. Time period (eight time periods were specified for weekdays, six for weekend days).

Quantitative Variables - Means and Standard Deviations of Their Distributions

A number of analyses were carried out for quantitative dependent variables that referred to properties of distributions generated for segments of trips and for complete trips. For such distributions we obtained as descriptive statistics (1) means (indices of typical values), and (2) standard deviations (indices of variability or dispersion of scores). Separate distributions for such quantitative variables were obtained by classification of the trip variables against the dependent variables: (1) type of day (weekday, weekend), (2) time period, (3) purpose of trip, and (4) trip segment string. The quantitative variables upon which these analyses were carried out were elapsed time from last trip, trip start time, trip complete time, trip elapsed time, trip distance, trip stops engine on, trip stops engine off, trip idling time, and trip average speed. The results of these computations were used to examine differences in trip descriptors under different time slot, trip purpose, and trip segment string configurations. There were 512 sets of such trip description data for each weekday variable and 384 for each weekend variable.

Trip segment variables were analyzed in a similar way. Here the variables were grouped into sets on the basis of: (1) type of day (weekday or weekend), (2) time period, (3) purpose of trip, and (4) segment type. Five types of segments were specified:

1. Nonfreeway segment in a nonfreeway trip.
2. Nonfreeway segment preceding a freeway segment.
3. Nonfreeway segment following a freeway segment.
4. Nonfreeway segment between two freeway segments.
5. Freeway segment.

The computation of frequencies of occurrence, means and standard deviations was carried out on the following segment descriptive variables: start time, complete time, elapsed time, distance, stops engine on, stops engine off, idling time, and average speed. This analysis required 640 sets of data for each weekday segment variable and 480 sets for each weekend segment variable.

These results were used to assign quantitative values to typical trip segments to show variation in the quantities with type of day and time of day and to test the following hypothesis about nonfreeway segments in general. The survey initially contemplated three types of roads for classification purposes: stop and go, arterial, and freeway. In designing the survey, we knew that a problem would arise with respect to the participant's ability to distinguish between stop and go and arterial routes. It is difficult to provide a sharp definition of each that can be easily used by the driver. Two distinct effects could therefore be anticipated in the results of the data. Either the values of the variables related to the two types of routes would be indistinguishable because of individual differences between drivers' interpretations of the type of route they were on, or else the values would indicate by their disparity that the drivers had defined the type of route as arterial or stop and go with respect to the amount of traffic congestion they were experiencing. Using the overall segment statistics in combination with statistics classified by route type, day type, and time period we carried out statistical tests to determine if either of these effects were discernible in the results. It turned out that the first effect was the one that occurred, namely that there was no distinction apparent in the results between arterial and stop and go route types. Consequently, all results were based on only two route types, freeway and nonfreeway.

Trip-to-Trip Transition Matrix Analysis

A key to the analysis of typical driving patterns is the trip-to-trip transition matrix. This is a somewhat mere sophisticated form of contingency table and was derived in part from past experience with Markov Chains. Initially, in the preparation of the draft final report, these matrices were used only for developing the typical n-trip patterns. It was later decided to apply them more generally. The matrix shows the count of $(j-1)^{\underline{st}}$ trips that transition to $j^{\underline{th}}$ trips under any set of conditions the analyst wishes to specify. The matrices were used primarily to show time-purpose dependencies between trips in the present study. The computer programs to prepare these matrices were developed especially for this project using corporate funds.

Certain problems with these trip-to-trip transition matrices were encountered due to programming problems still not entirely solved. In the train of (n-1) matrices necessary to describe transitions on n-trip days, certain random anomalies cropped up where one or two trips disappeared or were added from one matrix to the next, or changed cell position between succeeding matrices. These anomalies are apparently random and are caused by discrepancies in the basic data tape, not in the matrix preparation program. In all cases, the number of anomalies is too small to cause significant changes in the overall results.

Interpretation of Results

Interpreting the results of the computer analyses was a three-step process. First, daily activity patterns were detected using the distribution of the number of trips per day and the trip-to-trip transition matrices. Second, the pattern of trips within the daily pattern was examined using the contingency tables and the breakdowns of means and standard deviations by day type and time period classification. Finally, trip and segment variables were assigned values based on the analyses carried out for segments and for trips classified by day type, time period, purpose, and trip segment string.

Daily Patterns

The basic source for detecting daily trip activity was the distribution of trips per day. This tabulation showed which days, classified in number of trips per day, constituted a sufficiently large number of cases to warrant further analysis. For such days we had trip-to-trip transition matrices prepared that would show the typical daily pattern.

For an n-trip day, n-1 trip-to-trip transition matrices were output by the computer. To determine the typical time period relationships for the first and second trip, the row of the first matrix that had the largest number of entries was entered. The cell in that row with the largest number of entries represented the typical transition from trip one to trip two. The columns for this entry then became the row at which the next matrix was entered to determine the typical time relationship between the second and third trips. This process was continued for the third matrix and so on. When no clear-cut pattern was discernible, adjacent cells were examined in terms of a typical scenario to see if some entries in them could reasonably be combined with the cell under consideration. In some cases, no pattern could be determined. Such was the case with the six, seven, and eight-trip days. The number of cell entries was too uniformly distributed to enable the detection of a pattern in the early matrices and as the number of trips increased, the only pattern to be seen was that succeeding trips took place in later time periods.

Trip Patterns

Knowing the typical time-ordered transition process from trip-to-trip within the day, we had to assign typical trip patterns to each trip. At this stage of the analysis, a trip pattern consisted of a segment string. The contingency tables showing the joint frequencies of occurrence of trip segment string and purpose by time period and day type was examined to note any variation over the day or between weekday and weekend periods. Up to this point, all time-oriented analysis was restricted to the time periods agreed upon by SDC and CRC.

Upon entering the third step in the synthesizing of average trip patterns, time-ordered daily patterns for days having from two to five trips had been detected and within each pattern a trip segment string had been assigned to each. In order to assign quantitative values to each segment variable the tabulation of means and standard deviations for segments and segment pairs classified by day type and time period were used. Values for freeway segments and for nonfreeway segments preceding and following freeway segments were obtained from the segment class analysis. Values for single segment trips were obtained from data classified by single segment trips.

Finally, the data were all gathered together in a single tabulation for inclusion in this report as the Results of the Study.

APPENDIX I

TACHOGRAPH INSTALLATION

According to original plans the installation and removal of the Tachograph instruments was to be accomplished by the Argo Corporation on a subcontract basis. SDC was to arrange for all volunteer participants, coordinate the installation and removal schedule with participating organizations, and provide general field supervision of installation operations.

The Argo Corporation gave a firm price for installing the Tachographs on a per instrument basis, and it was this price that SDC used to compute its estimate of total costs for Tachograph installations. The Argo Corporation, however, did not indicate during negotiations that the price quoted was for installing only and would not cover the cost for removal of the Tachographs. When the removal price was combined with the installing price, the total installation costs were increased by 50 percent. Based upon this, it was decided to use SDC personnel to perform the installation operation.

Since SDC personnel were not familiar with the Tachograph instruments, the Argo Corporation agreed to train them in installation and removal procedures. This training was accomplished during the installation period at SDC.

Installation Scheduling

The survey plans called for the installation of ten Tachograph instruments per day for a maximum of 50 installations per week. Those organizations having ten or less participants would have the instruments installed on one day and removed on the same day the following week. For those organizations providing more than ten participants, installations were to be scheduled on a successive weekly basis. That is, for an organization with a survey sample of 30, installations were to be scheduled for three successive Mondays. This would allow the ten instruments installed on the first Monday to be removed from the survey vehicle on the second Monday and reinstalled in the next ten cars from the same organization. Such a schedule would simplify the logistics problem that would be encountered in a successive day installation schedule, i.e., Monday, Tuesday, and Wednesday, in that instruments would not have to be removed from one set of vehicles at the end of a survey week and transported to a different location for installation in another set of vehicles.

In order to establish a working schedule on this basis, it was necessary to have the survey samples set for at least five organizations prior to the first week of installations. As it happened, only one organization returned their completed questionnaires on time, and with the time constraints imposed by having to complete the vehicle survey by early August, it was necessary to adapt a successive day schedule.

In spite of the anticipated logistics problem of having to move instruments from one location to another on a daily basis as well as a continuing problem of not receiving the completed questionnaires from participating organizations at appointed times, the installations proceeded as scheduled (see Figure A-1).

Installation Procedures

The volunteer participants selected from within an organization delivered their vehicles to a prearranged installation area that is equipped with electric power and necessary lighting conditions. To minimize the disruptiveness of the activity, survey participants were logged in a registration system prior to their normal working hours. The registration procedure accomplished several functions. It permitted identification of the vehicle by license number for later use and identification, relative to the installation schedule, of those participants who failed to report or arrived in the wrong vehicle. A previously appointed alternate was then contacted during office hours and was requested to deliver his vehicle for use in the survey. This technique enabled the project to meet a daily quota goal of ten cars. Circumstances occasionally prevented that quota from being achieved. The participant registration form is shown in Figure A-2.

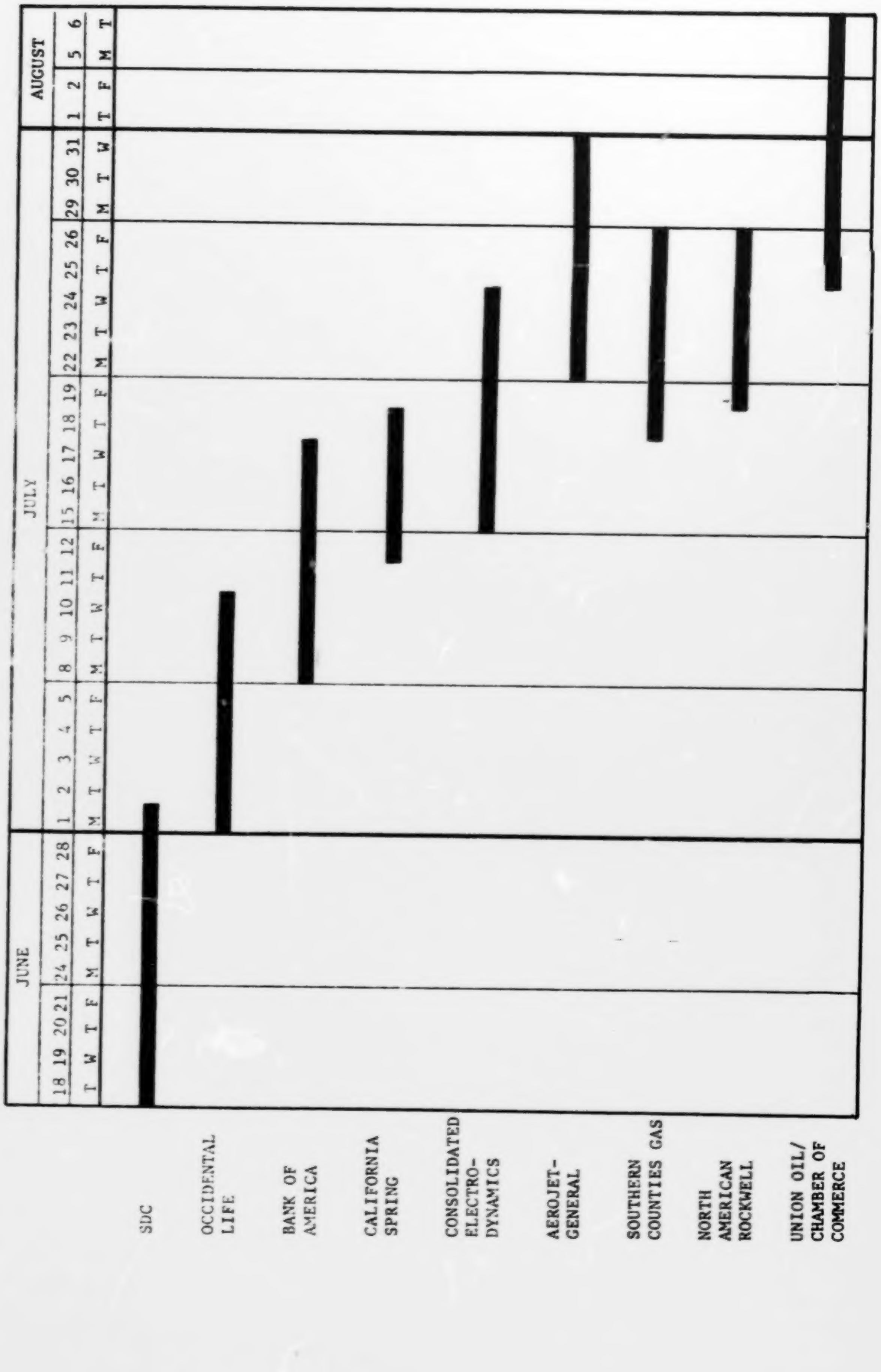


FIGURE A-1

LOS ANGELES TACHOGRAPH INSTALLATION SCHEDULE

Date ______________

Working Hours ______________

Company ______________

Address ______________

Phone No. ______________

NAME	TYPE OF CAR	LICENSE NUMBER	PHONE EXT.	TACH NO.	INSTALLATION COMPLETED			REMOVAL COMPLETED			REMARKS
					YES	NO	REASON	YES	NO	REASON	

FIGURE A-2

LOS ANGELES TACHOGRAPH INSTALLATION REGISTRATION FORM

Vehicles were then processed for the Tachograph installation. Frequently, a participant requested priority attention and whenever possible, an accommodation was granted. Prior to the installation of the Tachograph, the vehicle was examined for qualification. When it was determined that technical limitations disqualified a vehicle, the owner was contacted and advised of our action. As in the previous case, an alternate was requested to become a survey participant. Disqualification occurred when the vehicles' hardware configuration prevented access to or use of the transmission with a speedometer cable adapter. A good example of such a vehicle is one which contains a floor shift console between the two front seats and/or an air conditioning system which blocks entry into the vehicles' existing speedometer. In addition, vehicles not in sound operating condition were also disqualified. The following is a list of disqualified vehicles compiled from experience gained during the Los Angeles survey:

GENERAL MOTORS CORPORATION

- Buick Opel Cadet
- Corvette
- El Camino
- El Dorado
- Oldsmobiles
- Pontiac Firebird

FOREIGN CARS

- Austin Healey
- English Hillman
- Jaguar
- Mercedes-Benz
- M.G.
- Peugeot
- Porsche
- Renault
- Rover
- Alfa Romeo
- Sunbeam

FORD MOTOR COMPANY

- Cougar
- Lincoln
- L.T.D.
- Mustang
- Ranchero
- Thunderbird

CHRYSLER CORPORATION

- Barracuda
- Dodge (pre-1966)
- Plymouth (pre-1966)

STUDEBAKER

- Studebaker

GENERAL

- All Air Conditioned Fords
- All Station Wagons

Once a vehicle was determined to be qualified, the Tachograph was mounted in the trunk and the speedometer cable adapter was fastened to the transmission or the existing speedometer. Determination of adapter device to be used normally depended on the make of vehicle. Experience has shown that vehicles which accept the cable adapter at the transmission will provide more satisfactory data during the survey period. The reason for this is that the automobile speedometer cable is less apt to break. Cars equipped with speedometer adapters are subjected to excessive stresses causing cable breaks and subsequent loss of recorded data. More permanent installations are able to circumvent this problem. A photograph of a typical in-trunk installation of the Tachograph is included in Appendix I.

The standard configuration of the Tachograph provides for the mechanical recording of such data as speed, distance traveled, and idling time. To obtain data on the type of road being traveled, however, a modification to the instrument to include a dual relay was necessary. The relay, operated by 12 volts supplied by the line between the ignition switch and the coil, is actuated by the driver by means of a switch. This switch, when actuated, provides information on the road type (arterial highway, freeway or limited access, stop and go) the vehicle is traversing at a given time. This switch, normally fastened to the dashboard, connects to the Tachograph. One wire from the road switch is connected by an alligator clip to the ignition line. The possibility of electrical damage to the car and/or the Tachograph is eliminated by means of a six ampere fuse between the switch and the alligator clip.

Upon completion of the tasks described above, the cables were connected to the Tachograph. After the disc pack was installed and the mechanical clock wound, and while the vehicle remained on jacks, a primary test was conducted. This, the first of several tests, determined total system operation by running the engine at approximately forty (40) miles per hour for several moments. After engine shut-off, system operation was verified by viewing the recording trace in the Tachograph.

Test two, conducted one hour or more after installation, consisted of reviewing the disc for recording continuity of all four traces. At the termination of test two, the road switch is moved to the middle position (freeway, interstate, expressway or the like). One hour later, the recording was again reviewed to insure that the Tachograph relays, the switch, and the recording styli were functioning properly.

Following installation, the survey participants were assembled and briefed. At that time, usually just prior to the conclusion of their work day, the participants were advised of the additions to their vehicle and procedures to follow in event of nonoperative speedometer difficulties. Instructions in the use of the log book and the road switch were discussed in detail to ensure accurate participation.

Deinstallation Procedures

Survey participants returned their vehicles to the installation location on their way to work on the eighth day of operation.

After removing the Tachograph, switch, and associated cabling and wiring, and permanently sealing the holes required to accommodate the survey equipment, the vehicle was restored to its presurvey condition. A final test, under normal driving conditions, ensured that the vehicle was returned to its owner in proper operating condition.

APPENDIX II

INFORMATION/QUESTIONNAIRE PACKET

Following is a sample of the Information/Questionnaire Packets which were used to recruit volunteer survey candidates from within each participating organization. The packet consists of a two-page narrative describing the purpose of the survey, a picture showing a typical in-trunk installation of a Tachograph instrument, and a questionnaire.

The participating organizations were provided quantities of the packets and asked to distribute them among their employees. Those individuals wishing to volunteer completed the questionnaires and returned them to their supervisors. At a given time all completed questionnaires were sent to SDC where they were analyzed to determine each organization's particular driving picture, and samples of survey candidates were chosen which best represented these pictures in terms of the established stratification criteria.

Public Systems Division
SDC SYSTEM DEVELOPMENT CORPORATION
2500 Colorado Avenue, Santa Monica, California 90406

February 28, 1969

DRIVER PATTERN SURVEY

We are requesting your participation in a scientific study directed toward better control of automobile generated air pollutants.

System Development Corporation (SDC) of Santa Monica, California, is studying driving patterns in selected communities across the nation. SDC will perform the study for the Air Pollution Research Advisory Committee. Information derived from the study will be used to examine in greater detail the causes of air pollution.

So that you may have some appreciation of the scope of the project, the information to be obtained will be used to define driving patterns within each of six cities. In the United States, twelve hundred vehicles will be fitted with automatic recording instruments to obtain data on individual driving patterns. Should you be selected as a participant in this study, your automobile will be equipped with the recording device at our expense (see enclosed picture). The recorder will be mounted in the trunk of your vehicle where it will remain for one week. In addition, a switch will be fastened to your dashboard. These items will not damage your automobile; they will not affect your safety, nor the safety of any occupants in your vehicle at any time. Only a few small holes will be drilled in the trunk which will be plugged after the instrument is removed. You will not be required to do any unusual driving, nor will you have to drive any more than you normally do. At the conclusion of the recording period, the instrument and the switch will be removed from your vehicle, again at our expense.

The information which is recorded will indicate, relative to time of day, the distance you traveled each time you moved your automobile; the number of trips you made; the number of stops and starts you made; and the number of times you increased and decreased speed. All the above information will be recorded automatically. It is necessary, however, that we associate the above data with information about the type of road being used, i.e., freeway or interstate, residential and business, or arterial. That information must be provided by manually selecting a switch position as you change from type of road to another. Each day will be represented by a new recording disc which will be automatically positioned within the recorder. At the termination of the test period, the recordings are returned to our home office for detailed mathematical analysis by powerful computers.

Note that the questions you are being asked to answer in the accompanying questionnaire will provide information on whether you own one or more cars, which car(s) you would volunteer to be equipped with recording instruments, the number of miles you drive to work, etc. These questions have been carefully designed to select the appropriate statistical requirements. Accordingly, the information you provide will assist us in deriving the most appropriate sample data in your community.

Regardless of whether or not you are selected to participate in this project, your name will not be provided to any other agency for any other purpose. The information we obtain from your driving habits will be treated as an independent test case without use of your name, your address and your license number. This is our assurance that your privacy as a citizen will be maintained.

Although funds are not available to compensate you for your voluntary participation, you may take pride in the knowledge that you are contributing to a process intended to cleanse the air we breathe. We shall be pleased to submit to you a copy of your own driving pattern and of the average pattern in your community, along with instructions which will enable you to evaluate your pattern, should you agree to participate.

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NOT REPRODUCIBLE

This is a typical in-trunk installation of the ARGO Tachograph--the automatic data recording instrument used in the Driver Pattern Survey.

DRIVER PATTERN SURVEY QUESTIONNAIRE

1. What is the make, model and year of your car(s)?

	MAKE	MODEL	YEAR
a. First car	________	________	________
b. Second car	________	________	________
c. Third car	________	________	________
d. Which car do you normally drive to work?	( )a	( )b	( )c
e. If your spouse works and drives to work, which car does he (she) normally drive?	( )a	( )b	( )c
f. Approximately how many miles is each car driven per week?	( )a	( )b	( )c

2. Which car(s) would you be willing to volunteer for instrumentation?

( ) a   ( ) b   ( ) c

3. Approximately how many miles do you drive one way to work?

( ) 1-10   ( ) 11-20   ( ) 21-30   ( ) More than 30

4. In what general direction is your home from your office?

( ) N   ( ) NE   ( ) E   ( ) SE

( ) S   ( ) SW   ( ) W   ( ) NW

5. What type of residence do you occupy?

( ) Single family (house, condominium)

( ) Multi family (duplex, apartment, etc.)

6. Name (Please Print)________________________________

7. Address (Please Print)________________________________

8. Office telephone________________ Extension________________